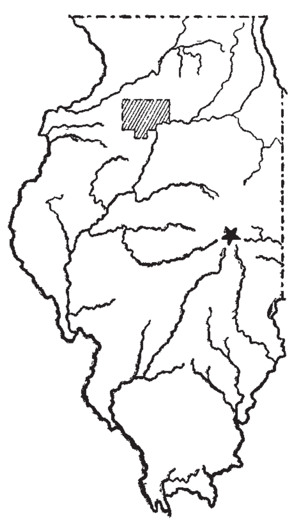
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 20

BUREAU COUNTY SOILS

BY J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
AND F. W. GARRETT
PREPARED FOR PUBLICATION BY L. H. SMITH



URBANA, ILLINOIS, DECEMBER, 1921

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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SUPPLEMENT

BUREAU COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, and F. W. GARRETT
Prepared for Publication by L. H. SMITH[1]

FORMATION

Bureau county is located in the west central-northern part of Illinois, the northwest corner being about twenty-six miles from the Mississippi river. There is much variation in the soils, due to the many agencies that have been instrumental in their formation. The northwestern part of the county is in the sand and gravel terrace formed by the Rock and Green rivers. An extension of this terrace to the southeast that reaches to Bureau creek without doubt indicates a former connection between the Rock and Illinois rivers.

During the Glacial period snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country from the far north the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, and boulders. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other, producing large quantities of rock flour. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was deposited, accumulating in a broad undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered.

THE GLACIATIONS OF BUREAU COUNTY

During the Glacial period there were six distinct and separate glacial advances as follows, in order of their occurrence:

(1) The Nebraskan, which did not touch Illinois. (2) The Kansan, which covered parts of Hancock and Adams counties. The Weymouth soil was developed from the surface of the Kansan glacial material. (3) The Illinoisan, which covered all of the state except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. The Sangamon soil was formed from the surface of the Illinoisan drift. (4) The Iowan, which covered a part of northern Illinois. The area covered by this advance is difficult to determine because of the later glaciations. At about the close of the Iowan glacial advance, loess or wind deposits were made. The surface of this material was formed into the Peorian soil, which was buried by the early Wisconsin glaciation. (5) The early Wisconsin glaciation, which covered the northeastern part of the state as far west as Peoria and

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[1] J. G. Mosier, in charge of soil survey mapping; S. V. Holt, in charge of field party; E. Van Alstine, in charge of soil analysis; F. W. Garrett, in charge of experiment fields; L. H. Smith, in charge of publications.

south to Shelbyville. (6) The late Wisconsin glaciation, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

Only three of these glacial advances covered all or part of Bureau county, burying the old soils and producing new ones. The first of these was the Illinoisan glacier, which probably covered the entire county. Subsequent glaciers covered most of this deposit leaving the Illinoisan drift exposed only in the southwestern part of the county, including Towns 15 North, Ranges 6 and 7 East, and the western tier of sections in Town 14 North, Range 8 East. A system of moraines extends across the first two townships and marks the northern limit of the exposed Illinoisan drift. The Illinoisan glacier was followed by the Iowan, which covered most of the county north of Town 15 North. Nearly all of the Iowan drift, however, has been covered by a subsequent glacier. The map, page 3, shows the approximate area of the Iowan glaciation now exposed.

The latest glacial advance that reached this county was the early Wisconsin, which covered the eastern two-thirds of the county and built up a very extensive moraine known as the Bloomington morainic system. This forms the ridge upon which Providence and Milo are located. This moraine extends to the northward and forms the divide between the Rock and the Illinois rivers. In the northeast part of the county the Bloomington system is formed by two ridges, an outer or western, and an inner or eastern ridge, the latter of which passes out at the northeast corner of the county. The Illinoisan moraine in the southwestern part of the county extends southeastward and merges with the Bloomington moraine. A fourth glaciation, the late Wisconsin, did not reach the county, but the water from the melting ice and the sediment which it carried down the Rock river undoubtedly played an important part in the formation of new soils and the modification of the old ones in the northwestern part of the county.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were encountered by the glacier, and both large and small masses of these were torn from their resting places by the enormous denuding power of the ice, ground up more or less together, and moved along with the glacier and later deposited as the ice melted. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds and possibly thousands of feet in thickness. The ice, together with the boulders and pebbles carried in it, thus became a powerful agent for grinding and wearing away the surface over which it passed. Ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. When the ice melted, this material was deposited, and it is known as boulder clay, till, glacial drift, or simply drift.

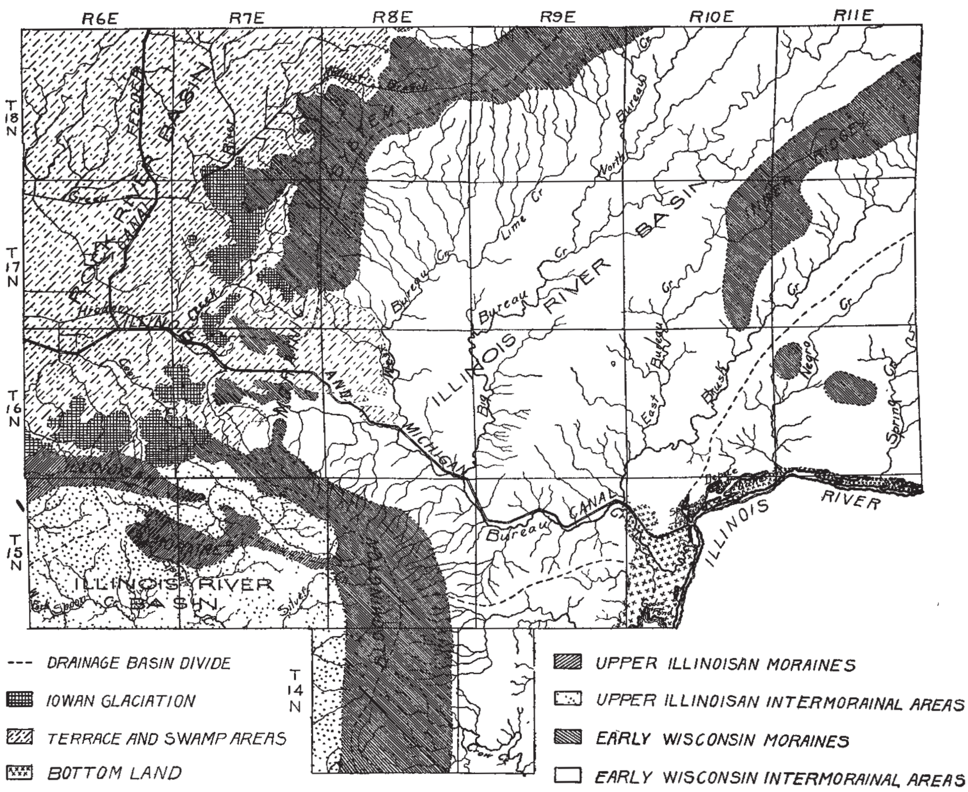
The thickness of this deposit in Bureau county varies from a few feet to about 600 feet, the greatest depth being in the old valley thru which the Rock river is supposed to have reached the Illinois. The average depth of drift in this county is at least 200 feet, and may possibly be as much as 300 feet. In many places strata of sand occur in the glacial drift. Old soils and fragments of trees are frequently encountered in the drift at depths as great as 130 feet. These soils represent interglacial periods when the glaciers receded, during

which ordinary conditions prevailed. It is believed that the drift in this county is deeper than any other in the state. The till, especially at a few feet in depth, is of a bluish color, and is commonly designated as blue clay.

PHYSIOGRAPHY AND DRAINAGE

Bureau county varies in topography from hilly to flat. These variations are due: first, to deposition of material transported by streams; second, to irregular deposition of material carried by glaciers; third, to material piled up by the wind, giving a dune topography; and fourth, to erosion by streams. The material deposited by streams gives rise to flat or very slightly undulating flood plains or older terrace deposits. These are found principally along the Illinois river, Bureau creek, and the Green river. In some cases the terrace deposits are slightly rolling, owing probably to the deposition of bars in broad, rather strong, currents of water.

The peculiar topography of glacial areas is due to the fact that the drift material was not uniformly distributed thruout the mass of ice, and when the ice melted it left the material in irregular heaps. The morainic areas are characterized by a peculiar billowy topography produced by the irregular piling up of material at the end of the glacier and by the covering up of ice masses in the moraines which, when they melted, produced depressions. The intermorainic areas vary in topography to a slight extent, giving a gently rolling character to the land.



MAP SHOWING THE DRAINAGE BASINS OF BUREAU COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND, AND SWAMP AREAS

The dune topography occurs in the northwestern part of the county within the terrace area and on the adjacent uplands. The terrace, during the time of the melting glacier, was largely covered by water and received deposits of gravel, sand, and finer material. Much of the sand and silt was reworked by the wind and piled up into dunes. The erosion topography occurs along nearly all streams outside of the terrace area. The east side of the Bloomington moraine in the southern part of the county is rather badly eroded by a large number of small streams.

There are three rather distinct drainage areas in the county: one in the southwestern part (the Spoon river basin, which is a part of the Illinois basin); one in the northwestern part (the Green river basin, which is really a part of the Rock river); and one in the eastern and southeastern part, which drains either directly into the Illinois river or into Bureau creek, which flows into the Illinois. Approximately two-thirds of the county is in this last drainage area. The county originally contained a large area of swamp land that has recently been drained into the Green river by means of dredge ditches.

The altitudes of some places in Bureau county are as follows: Arlington, 762 feet; Buda, 767; Bureau Junction, 480; Casbeer, 746; Depue, 472; Green Oak, 725; Ladd, 653; La Moille, 803; Malden, 705; Manlius, 795; Milo, 885; Mineral, 636; Neponset, 829; New Bedford, 650; Ohio, 917; Princeton, 718; Providence, 975; Spring Valley, 465; Sheffield, 671; Tiskilwa, 519; Van Orin, 807; Walnut, 714; Wyanet, 656; Yorktown, 638; Zearing, 761.

The highest point recorded in Bureau county occurs on the Bloomington moraine northeast of Providence, where the land rises to 987 feet above sea level. About a mile north of the village of Ohio the same moraine attains a height of approximately 940 feet. The lowest point in the county is 431 feet, giving a range of 556 feet in altitude. The Bloomington moraine, representing the outer edge of the Wisconsin till sheet, has a number of points over 900 feet in height. To the east of this moraine the drop is somewhat gradual until a height of approximately 750 feet is reached, while to the west of this moraine the drop reaches 650 feet. This gives about 100 feet more of relief to the west than to the east. One decided break occurs in the moraine, thru which the canal passes at the present time and which at one time formed the valley thru which the Rock river probably flowed to the Illinois.

SOIL MATERIAL AND SOIL TYPES

Altho the county has been largely covered by glaciers, the glacial drift does not constitute any large part of the material from which the soils have been derived directly. The county has been covered by a stratum of wind-blown or loessial material that varies from four to twelve feet or more in thickness. This constitutes the material from which the soil has been formed. In the terrace region in the northwest part of the county, the streams have mixed this to a greater or less extent with material, often coarser, that has been carried and deposited by them.

In general, the loessial material is deeper on the Illinoisan and Iowan drift, because, being older, there has been more time for deposition. It is also deeper on the flat areas than on the rolling ones because of the fact that erosion has removed much from the rolling land, in some cases leaving the glacial drift ex-

TABLE 1.—SOIL TYPES OF BUREAU COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)			
-26	Brown silt loam	461.56	295,398	53.41
-60	Brown sandy loam	20.21	12,934	2.34
-20	Black clay loam	1.53	979	.18
-25	Black silt loam	7.52	4,813	.87
-28	Brown-gray silt loam on tight clay	.13	83	.01
-81	Dune sand	.25	160	.02
-90	Gravelly loam	1.57	1,005	.18
		492.77	315,372	57.01
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)			
-34	Yellow-gray silt loam	78.37	50,157	9.07
-35	Yellow silt loam	56.88	36,403	6.58
-64	Yellow-gray sandy loam	.21	134	.02
		135.46	86,694	15.67
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	59.65	38,176	6.90
1560	Brown sandy loam	27.94	17,882	3.24
1561	Black sandy loam	13.48	8,627	1.56
1581	Dune sand	10.79	6,906	1.25
1550	Black mixed loam	3.93	2,515	.46
1525	Black silt loam	4.92	3,149	.57
1564	Yellow-gray sandy loam	4.96	3,174	.58
1571	Brown fine sandy loam	1.82	1,165	.21
1520	Black clay loam	.66	422	.08
1568	Brown-gray sandy loam on tight clay	2.44	1,562	.28
1536	Yellow-gray silt loam over gravel	3.31	2,118	.38
1564.4	Yellow-gray sandy loam on gravel	.33	211	.04
1560.4	Brown sandy loam on gravel	.12	77	.01
1528	Brown-gray silt loam on tight clay	.17	109	.02
1590	Gravelly loam	.17	109	.02
		134.69	86,202	15.60
	(d) Swamp and Bottom-Land Soils (1300, 1400)			
1354, 1454	Mixed loam	39.81	25,478	4.61
1401	Deep peat	10.00	6,400	1.16
1402	Medium peat on clay	3.22	2,061	.37
1410	Peaty loam	17.07	10,925	1.98
1420	Black clay loam	.25	160	.02
1425	Black silt loam	6.82	4,365	.79
1426	Deep brown silt loam	12.90	8,256	1.49
1450	Black mixed loam	.66	422	.08
1461	Black sandy loam	8.76	5,606	1.01
		99.49	63,673	11.51
	Water	1.82	1,165	.21
	Total area of county	864.23	553,106	100.00

posed. The various agencies that have been at work in the formation and transportation of soil material necessarily give the soils of the county a varied character. In addition to the transporting agencies, the accumulation of organic matter has gone on in the swamps and, to a slightly less extent, upon the uplands, and this together with the mineral material, has added to the complexity of the soils.

Many of the smaller streams originally did not have distinct channels, but flowed sluggishly in broad shallow valleys, or "sloughs." In some cases the streams flowing into these from the upland were sufficiently swift to transport fine gravel and coarse sand, while in other cases nothing but the finer material was carried. This has given rise to soils that contain some gravel and sand in areas where normally only fine material would be found.

The soils of Bureau county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with prairie grasses, the partly decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and the higher moisture content retarded their decay.

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas, of greater or less width, are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil type indicates.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two subclasses—the undulating and the hilly areas.

(c) Terrace Soils.—These include bench lands, or second bottom lands. They were formed by deposition from streams overloaded with coarse sediment during the melting of the glacier and subsequently. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the present overflow lands, or flood plains of streams, and the very poorly drained lowlands, where peats and peaty loams have been formed.

Table 1 gives the area of each type of soil in Bureau county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

INVOICE OF PLANT FOOD IN BUREAU COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 41, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Bureau county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, 22 times as much nitrogen as the dune sand, but it carries only one-fourth as much potassium as the brown silt loam. Similar variations are found with respect to the other elements.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found that the most common soil of Bureau county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus the condition differs only in degree. The brown silt loam contains no more of this element than would be required for fifteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for about 25 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Bureau county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the surface stratum presented in Table 2.

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE S

Average pounds per acre in 2 million pounds of surface soil (about 0-6 ⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)							
-26	Brown silt loam........	56 440	4 810	1 190	800	31 820	8 160	13 22
-60	Brown sandy loam......	27 190	2 390	670	580	21 890	4 600	6 14
-20	Black clay loam........	85 520	7 760	2 460	1 620	28 660	12 920	24 24
-25	Black silt loam.........	117 780	9 340	2 340	1 780	29 520	11 260	25 52
-28, 1528	Brown-gray silt loam on tight clay.........	47 340	4 420	1 420	980	32 160	5 020	8 76
-81	Dune sand.............	12 420	1 020	480	260	17 280	3 720	5 48
-90, 1590	Gravelly loam..........	25 040	2 600	760	780	31 840	47 520	91 42
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)							
-34	Yellow-gray silt loam...	40 480	3 910	1 240	700	32 200	5 960	12 05
-35	Yellow silt loam........	25 900	2 320	730	560	35 610	4 930	9 48
-64	Yellow-gray sandy loam.	18 360	1 440	460	380	23 260	3 360	6 08
	(c) Terrace Soils (1500)							
-27	Brown silt loam over gravel...............	46 620	4 070	1 040	800	31 030	8 130	12 61
-60	Brown sandy loam.....	36 100	3 080	1 000	860	22 540	4 800	8 10
-61	Black sandy loam......	74 640	7 100	1 560	1 080	22 400	7 700	19 50
-81	Dune sand.............	13 940	1 160	780	320	18 660	4 340	9 34
-50	Black mixed loam......	121 340	11 780	2 500	1 620	17 040	16 020	172 30
-25	Black silt loam.........	109 860	11 200	2 700	1 840	28 100	17 810	72 58
-64	Yellow-gray sandy loam.	28 020	2 160	980	640	29 160	4 780	10 98
-71	Brown fine sandy loam..	50 720	4 160	1 180	640	27 720	5 340	9 50
-20, 1420	Black clay loam........	86 560	7 240	2 520	1 360	31 580	14 740	25 60
-68	Brown-gray sandy loam on tight clay.........	40 240	3 410	970	650	24 880	4 210	9 51

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL, C

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	(c) Terrace Soils (1500), *Concluded*							
-36	Yellow-gray silt loam over gravel..........	18 880	1 920	760	700	33 420	7 200	11 34
-64.4	Yellow-gray sandy loam on gravel............	20 020	1 640	620	660	31 820	3 680	6 38
-60.4	Brown sandy loam on gravel..............	22 900	1 680	680	480	25 900	3 520	5 40
-28, 228, 528, 1128	Brown-gray silt loam on tight clay.........	47 340	4 420	1 420	980	32 160	5 020	8 76
-90, 290, 790, 990, 1190	Gravelly loam..........	25 040	2 600	760	780	31 840	47 520	91 42
	(d) Swamp and Bottom-Land Soils (1300, 1400)							
-54	Mixed loam...........	56 390	5 170	1 720	810	41 240	10 380	16 59
-01	Deep peat[1]...........	253 590	22 630	1 820	3 800	8 080	7 150	26 11
-02	Medium peat on clay[1]...	257 570	22 650	1 500	3 250	6 420	5 670	27 77
-10	Peaty loam...........	152 250	13 920	1 620	1 080	20 600	9 780	44 54
-20, 1520	Black clay loam........	86 560	7 240	2 520	1 360	31 580	14 740	25 60
-25	Black silt loam.........	155 000	13 960	2 540	2 860	26 620	12 660	34 68
-26	Deep brown silt loam...	86 740	7 220	2 080	1 460	41 960	14 840	43 52
-50	Black mixed loam......	105 160	10 160	1 800	1 120	24 600	5 500	16 00
-61	Black sandy loam	114 920	11 000	1 900	2 180	25 260	12 200	33 24

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inch

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)							
-26	Brown silt loam........	61 750	5 450	3 060	1 170	64 900	20 560	23 16
-60	Brown sandy loam......	35 130	3 170	1 230	910	48 990	11 770	11 16
-20	Black clay loam........	79 480	7 480	3 240	1 760	62 160	28 520	44 76
-25	Black silt loam.........	112 280	7 880	3 720	1 280	57 760	18 720	37 44
-28 1528	Brown-gray silt loam on tight clay.........	39 480	4 040	1 760	11 560	69 960	12 080	20 44
-81	Dune sand............	14 080	1 040	720	440	31 920	6 480	10 92
-90 1590	Gravelly loam..........	26 840	2 680	1 600	1 520	66 160	129 840	283 92
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)							
-34	Yellow-gray silt loam...	23 010	2 680	1 560	660	67 120	21 250	21 23
-35	Yellow silt loam........	13 620	1 580	1 400	740	75 940	16 760	22 04
-64	Yellow-gray sandy loam.	14 040	1 240	880	240	41 800	6 660	10 20
	(c) Terrace Soils (1500)							
-27	Brown silt loam over gravel...............	60 350	5 390	1 840	1 640	64 870	18 890	21 99
-60	Brown sandy loam.....	38 480	3 560	1 640	1 200	50 080	11 000	15 32
-61	Black sandy loam......	50 760	5 040	2 400	1 040	49 680	18 320	34 12
-81	Dune sand............	18 400	1 600	1 480	560	35 360	7 040	16 88
-50	Black mixed loam......	89 720	8 200	3 160	920	36 640	41 160	345 36
-25	Black silt loam.........	184 880	15 960	4 840	2 400	50 680	35 380	122 44
-64	Yellow-gray sandy loam.	16 040	1 960	1 840	1 000	65 440	14 560	16 08
-71	Brown fine sandy loam..	44 400	3 880	1 680	600	60 320	11 760	16 80
-20 1420	Black clay loam........	98 440	8 240	3 920	1 680	67 640	26 960	44 60
-68	Brown-gray sandy loam on tight clay.........	33 420	3 040	1 460	1 000	54 180	10 740	16 48

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(c) Terrace Soils (1500), *Concluded*							
-36	Yellow-gray silt loam over gravel	13 560	1 960	2 040	920	68 680	20 200	22 280
-64.4	Yellow-gray sandy loam on gravel	11 520	1 080	1 400	480	65 560	9 040	12 160
-60.4	Brown sandy loam on gravel	26 760	2 320	1 400	840	53 320	7 720	9 800
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440
-90, 290, 790, 990, 1190	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920
	(d) Swamp and Bottom-Land Soils (1300, 1400)							
-54	Mixed loam	82 460	7 640	3 000	1 480	83 680	26 560	40 920
-01	Deep peat[1]	506 730	45 070	3 230	7 980	12 600	12 780	56 670
-02	Medium peat on clay[1]	226 300	20 480	1 860	2 960	20 800	11 980	47 520
-10	Peaty loam	89 080	7 540	1 820	1 960	41 300	8 420	220 120
-20, 1520	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600
-25	Black silt loam	113 040	10 520	4 280	2 520	53 680	32 080	83 000
-26	Deep brown silt loam	98 280	8 400	3 240	1 760	77 640	34 520	78 560
-50	Black mixed loam	105 400	9 840	2 520	960	50 640	6 720	26 280
-61	Black sandy loam	98 680	9 520	3 000	1 800	57 640	29 320	56 960

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSOI

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)							
-26	Brown silt loam..	26 330	3 040	2 690	1 140	97 940	42 630	51 46
-60	Brown sandy loam......	20 180	1 560	1 420	980	68 060	16 440	17 70
-20	Black clay loam........	26 280	2 760	3 540	420	99 180	43 380	47 88
-25	Black silt loam.........	43 260	3 240	3 360	1 020	78 180	66 300	109 56
-28 1528	Brown-gray silt loam on tight clay.........	21 360	2 880	2 340	600	96 180	33 120	35 82
-81	Dune sand............	9 900	540	1 020	900	50 100	12 480	17 94
-90 1590	Gravelly loam..........	14 820	1 740	2 280	1 440	102 840	239 340	517 14
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)							
-34	Yellow-gray silt loam...	18 710	2 460	3 050	930	99 090	41 500	36 93
-35	Yellow silt loam........	12 930	2 070	2 910	900	122 790	41 340	33 18
-64	Yellow-gray sandy loam.	11 280	840	1 140	300	55 920	9 180	12 18
	(c) Terrace Soils (1500)							
-27	Brown silt loam over gravel...............	33 440	3 500	2 620	1 420	94 840	35 780	39 50
-60	Brown sandy loam......	18 420	2 160	1 680	1 320	57 960	14 280	19 14
-61	Black sandy loam......	31 800	3 360	3 240	1 440	82 980	36 480	61 92
-81	Dune sand............	15 960	1 200	2 040	780	55 140	14 280	20 22
-50	Black mixed loam......	40 740	3 600	3 600	60	80 940	45 360	164 10
-25	Black silt loam..... ...	64 260	8 880	5 300	1 740	81 540	59 590	193 98
-64	Yellow-gray sandy loam	18 900	1 500	2 400	1 020	68 460	18 420	19 56
-71	Brown fine sandy loam..	23 820	2 040	1 800	1 080	83 700	18 840	27 06
-20 1420	Black clay loam........	51 780	5 100	4 320	1 920	104 640	43 080	53 94
-68	Brown-gray sandy loam on tight clay........	20 220	1 890	2 220	1 170	69 720	18 450	22 32

Table 4.—Plant Food in the Soils of Bureau County, Illinois: Subsoil, *Con*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	(c) Terrace Soils (1500), *Concluded*							
–36	Yellow-gray silt loam over gravel	12 420	2 100	3 660	1 380	94 080	34 320	33 30
–28, 228, 528, 1128	Brown-gray silt loam on tight clay	21 360	2 880	2 340	600	96 180	33 120	35 82
–90, 290, 790, 990, 1190	Gravelly loam	14 820	1 740	2 280	1 440	102 840	239 340	517 14
	(d) Swamp and Bottom-Land Soils (1300, 1400)							
–54	Mixed loam	51 480	4 890	3 600	1 140	114 180	80 850	155 58
–01	Deep peat[1]	555 780	46 150	3 800	11 490	19 340	24 270	235 10
–02	Medium peat on clay	366 940	5 820	3 240	1 800	60 540	39 330	625 86
–10	Peaty loam	51 900	3 960	2 370	1 410	62 850	57 450	307 95
–20, 1520	Black clay loam	51 780	5 100	4 320	1 920	104 640	43 080	53 94
–25	Black silt loam	100 980	4 140	4 320	1 740	81 780	77 400	245 28
–26	Deep brown silt loam	50 640	4 920	3 540	1 500	112 260	108 240	201 72
–50	Black mixed loam	62 340	4 680	4 620	300	73 980	15 420	42 84
–61	Black sandy loam	54 960	4 680	4 560	1 320	93 240	57 060	157 26

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Bureau county cover 492.77 square miles, or 57.01 percent of the area of the county. They are usually either brown or black in color, owing to the large organic-matter content. They occupy the less rolling, but not swampy, areas.

Brown Silt Loam (226, 526, 726, 926, 1126)

The brown silt loam is the most important as well as the most extensive type in Bureau county. It covers an area of 461.56 square miles, or 53.41 percent of the area of the entire county. This type occupies the slightly undulating to rolling areas of the prairie land, both morainal and intermorainal. The irregularities are due in a slight measure to erosion, but primarily to irregular deposition of material by the glaciers. While surface drainage is generally good, there are many places where the use of tile is necessary to remove the excess of water, and it is doubtless true that tile could be advantageously used to a greater extent than it is being used at present.

The soil is formed from a wind-blown or loessial material which covers the region to a depth of from two to twelve feet, the deeper deposit being over the Illinoisan and Iowan drift sheets. This material is mostly composed of the different grades of silt, the soil constituent intermediate in fineness. Altho brown silt loam is normally a prairie soil, yet in some limited areas forests have recently invaded it. They have not, however, changed it materially. These forests consist largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black-walnut soil is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter may become so reduced that the soil would then be classed as a timber type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying on the one hand to black as it grades into black clay loam (1120), or black silt loam (1125), and on the other hand to grayish brown or yellowish brown as it grades into the timber types. It contains a sufficient amount of the coarser constituents (coarse silt and fine sand) to make it work easily and yet enough fine silt and clay to give it stability and cause it to granulate. Where the brown silt loam occurs near the sandy loam, the type contains some sand and it may even include small areas of sandy loam that are not large enough to be shown on the map. It contains from 65 to 80 percent of silt, 10 to 15 percent of clay, and 15 to 30 percent of sand.

The organic-matter content varies from 3.7 to 6.6 percent, with an average of 5.2 percent, or 52 tons per acre. In the more rolling morainal areas there is less organic matter than in the low, richer, and poorly drained parts, the larger moisture content of the latter encouraging a ranker growth of grasses and roots and at the same time furnishing more favorable conditions for their pres-

ervation. The organic matter becomes less where the type grades into the yellow-gray silt loam (534, 934, and 1134).

The natural subsurface stratum varies from 9 to 16 inches in thickness, and from a dark brown or even black to a yellowish brown silt loam. Both color and depth vary with the topography, the type being lighter and shallower on the more rolling areas. Both the surface and subsurface are lighter in color where the type grades into the yellow-gray silt loam. The subsurface as sampled (6⅔ to 20 inches) contains 3.1 percent of organic matter, or 62 tons per acre. The natural subsurface is thicker in the lower, heavier, and poorly drained areas. This condition is due to the fact that deep cracks form in these low areas during periods of drouth, which allow some of the dark surface soil to be washed down by the rains, thus producing a deep layer of black soil.

The natural subsoil begins at a depth of 12 to 22 inches. It is a yellow or drabbish clayey silt or silty clay, somewhat plastic when wet. Where the drainage has been good, the color varies from a pale to a bright yellow, but where drainage has been poor it approaches a drab or an olive with pale yellow mottlings or a yellow with mottlings of drab, due to a lack of oxidation of iron.

The layer of loessial material is so deep that the drift rarely forms any part of the subsoil to a depth of 40 inches. Variations of the subsoil occur in limited areas adjacent to the sandy loam, and are due to the presence of more or less sand in the subsoil. In some small areas the subsoil passes into sand, indicating a sand deposit before the loess was deposited.

Treatment.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more readily. Unless the moisture conditions are very favorable, the ground plows up cloddy and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limits crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soils is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil, and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally; and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On much of the type, limestone is already becoming deficient. An application of 2 tons of limestone, where needed, and ½ ton of finely ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation of corn, corn, oats, and clover, will maintain the fertility of this type, altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be 4 tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. In either system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. For results secured in field experiments on brown silt loam, see page 52 of the Supplement.

Brown Sandy Loam (260, 560, 760, 960, 1160)

Brown sandy loam occurs chiefly in the western part of the county. It covers 20.21 square miles, or 2.34 percent of the area of the county. In topography it is somewhat undulating, owing to the fact that sand was deposited over much of the area in the form of low dunes. The soil was later formed from this sand. In other areas, the undulating character of the surface is due to irregular deposition of the glacial drift, while in still others the irregularities are due to erosion. In these latter cases sand has been added to the soil thru the agency of wind. Small areas of brown sandy loam have been covered with forest, but not long enough to change the character of the soil to any extent.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam, varying in color from black to light brown or yellowish brown. In sand content it varies from 50 to 80 percent, but the larger part of the area is of the more sandy phase, with approximately 65 to 70 percent of sand. The organic-matter content of the surface stratum varies from 1.6 to 3.4 percent, with an average of 2.3 percent, or 23 tons per acre. The amount is less in the more sandy phase, which usually occupies the more rolling or dune-like parts.

The natural subsurface varies from 6 to 18 inches in thickness and is mostly yellowish brown, brownish yellow, and yellow in color. The subsurface is not separated from the subsoil by a distinct line, but passes into it gradually, as indicated by the gradual change in color, and usually by an increase in sand content. The stratum is deeper on well-drained areas where roots are able to penetrate to a considerable depth. The amount of organic matter in the stratum sampled (6⅔ to 20 inches) varies from 1.3 to 1.7 percent, averaging 1.5 percent, or 30 tons per acre.

The natural subsoil begins at a depth of 12 to 24 inches. It varies in physical composition from a sandy silt to a yellow medium sand. The stratum 20 to 40 inches contains about .6 percent of organic matter.

Treatment.—This type is generally well drained. A few small areas need artificial drainage.

In the management of brown sandy loam, the organic matter should be increased or at least maintained by turning under farm manure, crop residues, and legumes. Organic matter, in addition to furnishing nitrogen, will prevent the movement of sand by the wind, which is very likely to take place on the more sandy areas as the organic content is diminished. On the very sandy areas, cowpeas or sweet clover are good legumes to grow. Ground limestone and organic manures are of the greatest importance in the improvement of this soil. While the total supply of phosphorus is much less than in the brown silt loam, the porous character of the subsurface and subsoil, which affords a deep feeding range for plant roots, is likely to more than counterbalance this lack, so that the application of phosphorus is not advised except where other limiting soil factors have been provided for. Initial applications of 3 to 4 tons per acre of limestone should be made with about 2 tons every four or five years thereafter.

Black Clay Loam (520, 920, 1120)

Black clay loam is one of the types that represent the flat, heavy, prairie land that is sometimes called "gumbo," because of its sticky character. Its formation in the flat, poorly drained areas is due to the accumulation of organic matter and the washing in of clay and fine silt from the slightly higher adjoining lands. This type occupies 979 acres, or .18 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, plastic clay loam varying to black clayey silt loam. It contains about 7.4 percent of organic matter, or 74 tons per acre.

The natural subsurface stratum has a thickness of 10 to 16 inches, and varies from a black at the top to a pale yellowish drab clay loam, usually somewhat heavier than the surface soil. The stratum as sampled (6⅔ to 20 inches) contains about 3.4 percent of organic matter, or 68 tons per acre. The stratum is pervious to water, owing principally to the jointing or checking from shrinkage in times of drouth.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. Concretions of carbonate of lime are sometimes found. The perviousness of the subsoil is about the same as that of the subsurface, and is due to the same cause. When thrown out on the surface where wetting and drying may take place, it soon breaks into small cubical masses.

Black clay loam grades into other types, especially into black silt loam and brown silt loam. The washing in of silty material from the higher surrounding land, especially near the edges of the area, gives the surface a silty character. This change is taking place more rapidly now than formerly, when washing was largely prevented by prairie grasses.

Treatment.—Drainage is the first requirement in the management of this type. It is easily tile drained where an outlet is obtainable. Keeping the soil in good tilth is very essential, and thoro drainage helps to do this to a great extent.

As the organic matter is destroyed by cultivation and nitrification, and as the limestone is removed by cropping and leaching, the physical condition of

the soil becomes poorer, and as a consequence it becomes more difficult to work. Both organic matter and limestone develop granulation, a very necessary condition for maintaining the tilth, especially of heavy soils. The organic matter should be maintained by turning under farm manure and crop residues, such as corn stalks and straw, and by the use of clovers and pasture in rotations.

Altho the sample collected in Bureau county shows no limestone present, this type is likely to vary in this respect. It is therefore advisable to apply the simple tests for limestone described in the Appendix (page 43), and in case limestone is not present this material should be applied at the rate of at least 2 tons per acre.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evaporates or is used by the crops, they shrink. This results in the formation of cracks which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by ''blocking out'' hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Both for aeration and as a means of producing a mulch for conserving moisture, cultivation is more essential on this type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the corn.

The results of field experiments on this type of soil are given on page 64 of the Supplement.

Black Silt Loam (225, 525, 725, 925, 1125)

Black silt loam occupies low, flat areas or sloughs, occurring in situations somewhat similar to those of the black clay loam (—20), but it has had more of the coarser material washed in, and as a result is somewhat friable and silty. It covers a total area of 4,813 acres. In topography, this type is flat and naturally poorly drained.

The surface soil, 0 to 6⅔ inches, is a black silt loam varying on the one hand to brown silt loam, and on the other to black clay loam, and even grading toward muck in some cases. It is quite granular, and as a result is very pervious to both air and water. It contains 10.1 percent of organic matter, or 101 tons per acre. This is one of the richest soils in organic matter excepting the peats.

The natural subsurface is from 12 to 16 inches thick, and is a black to a dark brown clayey silt loam becoming drab or yellowish drab at the beginning of the subsoil. The subsurface stratum (6⅔ to 20 inches) contains 4.9 percent of organic matter, or 98 tons per acre.

The subsoil is a yellow or drabbish yellow clayey silt that permits free movement of water.

Treatment.—In the management of this type the same precautions should be observed with respect to drainage and the maintenance of organic matter as in the management of black clay loam.

Brown-Gray Silt Loam on Tight Clay (228, 528, 1128)

Brown-gray silt loam on tight clay is found only in small isolated areas that cover altogether but 83 acres. These areas usually occupy depressions in which some peculiar conditions of drainage have produced this soil.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with areas of a grayish tint, especially when the soil becomes dry following a rain. The surface stratum contains about 4.1 percent of organic matter, or 41 tons per acre.

The subsurface is a gray silt loam becoming more yellow as the subsoil is approached. It is slowly pervious to water. This stratum contains 1.7 percent of organic matter. A sudden decrease in the organic matter content of the subsurface is characteristic of this type.

The subsoil is a tough, plastic, impervious clay, of a brownish gray or yellow color.

Treatment.—The first requirement of this type is good drainage, and this is somewhat difficult to secure at first because of the impervious character of the soil. After the soil is thoroly tile-drained, from 3 to 5 tons per acre of crushed limestone should be applied, and deep rooting crops, such as red, mammoth, or preferably sweet clover, should be grown. These legumes, along with any available manure and crop residues, should be turned under for soil improvement. Applications of from ½ to 1 ton per acre of rock phosphate should be made every four or five years until 2 tons have been applied.

Dune Sand (581, 781, 981, 1181)

The dune sand on the upland occurs as small, irregular patches scattered over the sandy-loam areas and widely distributed over the west half of the county. They represent the higher dunes of this county, which have never been covered with finer material or from which the fine material has been removed by wind and water. The total area is 160 acres, or .02 percent of the area of the county. This dune sand type does not differ from the terrace dune sand, and for further discussion of its character and treatment the reader is referred to the description of terrace dune sand (page 25).

Gravelly Loam (290, 790, 990, 1190)

Gravelly loam occurs principally in Towns 15 and 16 North, Range 7 East, in small irregular areas, and covers altogether 1,005 acres in this county.

The surface soil, 0 to 6⅔ inches, is a brown gravelly loam containing 2.2 percent of organic matter, or 22 tons per acre.

The subsurface is a light brown gravelly sandy loam, having an organic-matter content of 1.1 percent.

The subsoil is a yellowish or brownish gravel.

Treatment.—Where this type does not contain too much coarse material, good crops may be grown. It is necessary that the organic matter be maintained or even increased.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellow, yel-

lowish gray, or gray color, which is due to their facilities for oxidation and to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils comprize 135.46 square miles, or 15.67 percent of the entire area of the county.

Yellow-Gray Silt Loam (234, 534, 734, 934, 1134)

Yellow-gray silt loam generally occurs in the outer timber belts along streams. The type covers 78.37 square miles, or about 9 percent of the entire area of the county. In topography it is sufficiently rolling for fair surface drainage without much tendency to wash if proper care is taken.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or grayish brown, silt loam, pulverulent, but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type is a grayish yellow or brownish yellow. As the type approaches the brown silt loam it becomes decidedly darker. The organic-matter content varies from 2 to 3.5 percent, with an average of 2.6 percent, or 26 tons per acre. The greatest variation in the organic-matter content is found in the more rolling areas where erosion has taken place.

In some places it is extremely difficult to draw the line between the long-cultivated and somewhat eroded brown silt loam, and the yellow-gray silt loam. This is especially true in some parts of the upper Illinoisan glaciation, notably in Town 14 North, Range 8 East, and Towns 15 North, Ranges 6 and 7 East. Here the brown silt loam is quite rolling and the slopes have in some cases eroded sufficiently so that they are mapped as yellow-gray silt loam. They probably never have been timbered.

The variation in texture of the surface stratum is due, to some extent, to the irregular deposition of sand by the wind. In some of the yellow-gray silt loam areas near the former extensive swamp, sand has been blown onto the uplands, thus increasing the normal amount of sand to such an extent that some very small areas, not sufficiently large to map, are sandy loams.

The natural subsurface stratum varies from 3 to 5 inches in thickness on the more rolling parts and from 8 to 14 inches on the more level areas, with an average of about 10 inches. It is usually a gray, grayish yellow, or yellow silt loam. The organic-matter content of the stratum sampled (6⅔ to 20 inches) varies from .6 to 1 percent, with an average of .8 percent, or 16 tons per acre. The physical composition of the subsurface varies with the surface.

The subsoil is a yellow or a mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet, but friable when only moist. It is pervious to

water. The subsoil varies in physical composition even more than the surface stratum. Frequently boulder clay constitutes part or all of the subsoil. Sometimes sand may be encountered in the subsoil at a depth of from 30 to 40 inches. The sand was deposited by the wind previous to the deposition of the loess which constitutes most of the soil material of the upland in Bureau county.

This type drains well except on some of the more level and older forested areas, where a somewhat tough and tight clayey layer has developed that retards the movement of water.

Treatment.—In the management of yellow-gray silt loam, it is very necessary to maintain or even to increase the organic-matter content. This is necessary in order to supply nitrogen and liberate mineral plant foods; to give the soil better tilth; to prevent running together during heavy rains; and to prevent erosion on the more rolling phase. Rotations should be practiced that for a time at least will keep the soil in pasture, clover, or alfalfa, and reduce the tilled crops to a minimum acreage.

The samples analyzed showed considerable acidity especially in the subsurface. In such cases ground limestone should be applied in order that legumes may be grown successfully. An initial application of 2 to 4 tons per acre is suggested, after which 1 to 2 tons per acre every four or five years will probably be sufficient. Since the soil is poor in phosphorus, this element should be applied. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus, altho when prices are normal steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

For results from practical field experiments upon yellow-gray silt loam, see page 65 of the Supplement.

Yellow Silt Loam (235, 535, 735, 935, 1135)

Yellow silt loam occurs as hilly and badly eroded land on the inner timber belts adjacent to the streams, usually in narrow irregular strips with arms extending up the small valleys. The type covers an area of 56.88 square miles, or 6.58 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow friable silt loam. It varies greatly in color, owing to recent erosion. In places the natural subsoil may be exposed, and this gives it a decidedly yellow color. When freshly plowed the soil appears yellow or grayish yellow, but when it becomes dry after a rain it is decidedly gray. The surface soil in some places may be composed of boulder clay, which usually contains more or less gravel. The area of this, however, is very limited. Near sandy-loam areas the surface soil may be somewhat sandy and may even become a sandy loam, but these areas are usually too small to be shown on the map. The organic-matter content varies from 2 to 2.4 percent, with an average of 2.2 percent, or 22 tons per acre.

The natural subsurface varies from an inch or two to 12 inches in thickness, and is usually a yellow silt loam, altho on the steepest slopes it may consist of a clayey silt loam. In other places it may contain a considerable amount of sand. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 14 tons per acre.

The subsoil is normally a yellow clayey silt. On the more eroded areas, however, it may be composed in part or entirely of boulder clay or drift, and

where the wind has transported a great deal of sand the subsoil may be sandy or even a sand.

Treatment.—The first and most important point in the management of this type is the prevention of general surface-washing and gullying. If the land is cropped at all a rotation should be practiced that will require cultivated crops as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and to increase the organic-matter content. This will help to hold the soil and keep it in good physical condition so that it will absorb a large amount of water and thus diminish the run-off. (See Bulletin 207, "Washing of Soils and Methods of Prevention.")

According to the analyses of the samples of yellow silt loam collected in Bureau county, limestone is sometimes present in the subsoil but none of this material is contained in the surface or subsurface. However, it is known that in this general region of the state limestone occasionally occurs in abundance in the subsurface stratum. In view of this fact, therefore, it is recommended that the test for soil acidity, as described in the Appendix, be made. If this test indicates the absence of limestone near the surface, then this material should be applied at the rate of 2 to 4 tons per acre.

One of the best crops to be grown on land that is gullied or is likely to wash badly is sweet clover. This furnishes a large amount of good pasture and encourages the growth of blue-grass. Both the clover and the blue-grass tend to hold the soil and prevent washing. Alfalfa is another good legume crop to be grown on this type of soil. It will be useless, however, to sow either sweet clover or alfalfa if the soil is acid.

For an account of experiments with yellow silt loam soil the reader is referred to page 67 of the Supplement.

Yellow-Gray Sandy Loam (964, 1164)

The total area of yellow-gray sandy loam amounts to but 134 acres. It occurs along Bureau creek where the sand has been blown onto the upland.

The surface soil, 0 to 6⅔ inches, contains 1.6 percent of organic matter, or 16 tons per acre, and consists of a yellow or a grayish yellow sandy loam.

The subsurface contains .6 percent of organic matter, or 12 tons per acre. It is more sandy than the surface and passes into a yellow sand.

The subsoil is a yellow sand.

Treatment.—The primary consideration in the management of this type is the increasing of the organic-matter content. This may be done by turning under farm manure, crop residues, and legume crops. From 3 to 4 tons per acre of limestone may well be applied for the successful growing of clovers.

(c) TERRACE SOILS

Terrace soils have been developed on terraces or old fills in valleys. A large area in the northwestern part of Bureau county was formerly rather low and swampy. This is a broad terrace formed by deposits made by the Rock and

Green rivers during the period when the early and the late Wisconsin glaciers were melting. Large amounts of sand and gravel were carried down the flooded Rock river and were spread out over an extensive area in this part of the state forming a region known as the Winnebago swamp. This deposit is more than 200 feet deep. It is very probable that the old valley that connected the Rock river with the Illinois aided in producing the extreme width of the terrace in this region. Much of the sand that was deposited by streams was re-worked by the wind, producing the sand dunes of the county. Distinct terraces are found along Bureau creek and some of its tributaries as well as along the Illinois river. These were formed in the usual way by the partial filling up of the valley by overloaded streams which later cut down thru this fill, leaving the terrace from 20 to 50 feet above the present flood plain of the stream.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel covers 59.65 square miles, or nearly 7 percent of the area of the county. A few small areas occur along Bureau creek and its tributaries, but most of the type is to be found in the terrace region in the west half of the county. The topography varies from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown to a dark brown granular silt loam containing from 3.3 to 7.8 percent of organic matter, with an average of 5 percent, or 50 tons per acre. In this constituent it differs but little from the brown silt loam of the upland. In physical composition the soil varies from a dark brown clayey silt loam to a silt loam with a considerable percentage of sand. Occasionally very small areas of sandy loam occur which are not large enough to be shown on the map.

The natural subsurface stratum varies from 8 to 12 inches in thickness and is a brown to a yellowish brown silt loam, containing in many cases a perceptible amount of sand.

The subsoil usually consists of a pale yellow to a drabbish or grayish yellow, slightly clayey silt, but it varies considerably. In some places the subsoil is rather sandy and may even pass thru gray-colored sand, and in others some gravel is found mixed with the finer clayey material.

Treatment.—Much of the type has been artificially drained. The strata are pervious and afford ready movement of water. Gravel or sand is not usually encountered until a depth of 55 to 60 inches has been reached. This deposit would afford good underdrainage if the water table could be lowered sufficiently.

In the management of this type, organic matter must be maintained by every available means, especially on the undulating phase. The phosphorus content is slightly lower than that of the upland brown silt loam. With respect to phosphorus the same treatment is recommended as that given for the upland brown silt loam, page 14. Applications of from 2 to 3 tons per acre of limestone will in all probability be profitable for the growing of clovers.

Brown Sandy Loam (1560)

Brown sandy loam covers an area of 27.94 square miles, or 3.24 percent of the area of the county. It is confined mostly to the northwestern part of the terrace or swamp area. In topography, it varies from flat to somewhat rolling,

the rolling character being produced by sand dunes. In the sand dune areas it usually occupies the lower lying parts.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3.1 percent, or 31 tons per acre of organic matter. It varies in texture from a somewhat fine to a coarse sand.

The natural subsurface is about 14 inches in thickness and consists of a brown to a brownish yellow sandy loam, rather variable in sand content. The organic-matter content is 1.7 percent, or 34 tons per acre, in a stratum 13⅓ inches thick.

The subsoil varies from a yellow silty sand to a yellow sand.

Treatment.—All strata are pervious to water so that underdrainage takes place readily. Natural drainage is not always sufficient and therefore it is sometimes advisable to resort to artificial drainage.

After drainage, the maintenance of organic matter and nitrogen are the most important considerations in the management of this type. These materials may be provided by utilizing the farm manure produced and supplementing this by turning under corn stalks, straw, and clovers when these are not fed on the farm. Altho the content of phosphorus is not high, fair results may be obtained without the application of phosphorus because of the large feeding range of the plant roots in this loose soil. In time, however, as the content is reduced, applications of this element will doubtless be profitable. Since all strata of this type of soil are lacking in limestone, an initial application of 3 to 4 tons per acre of this material should be made, with 1 to 2 tons every four or five years thereafter.

Black Sandy Loam (1561)

Black sandy loam is found entirely in the terrace area in the northwest part of the county. It is most abundant in the vicinity of Green river, an area which was at one time occupied by an old lake or swamp. The topography is flat with only very slight undulations, rarely more than a foot or two in height. The total area covered amounts to 8,627 acres.

The surface soil, 0 to 6⅔ inches, is a black sandy loam, usually containing sufficient clay to render the soil slightly plastic. This stratum contains in the main about 6.4 percent of organic matter, or 64 tons per acre, altho the organic-matter content varies rather widely, and small local areas contain a sufficient amount to be classed as peaty loam. Soils of this kind do not usually possess plasticity.

The natural subsurface soil, which is from 14 to 16 inches in thickness, varies from black to brown in color, and passes into a yellowish sandy material in the subsoil. In some places a perceptible amount of gravel occurs. The stratum sampled (6⅔ to 20 inches) contains 2.2 percent of organic matter, or 44 tons per acre.

The subsoil varies from a yellow, drabbish yellow, or drab, clayey sand to a yellow or drab sand. It contains .9 percent of organic matter.

Treatment.—The type generally needs drainage. Drainage and good cultivation are the principal points in its management. Spots of alkali are frequently found on which corn does not do well, and where oats lodge badly. Applications of coarse stable manure, potassium salts, or a crop of sweet clover turned

under will enable a good crop of corn to be grown. Sweet clover does especially well on soil of this character. The black sandy loam is becoming slightly acid in many places.

Dune Sand (1581)

Dune sand of the terrace occupies 6,906 acres, or 1.25 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a light brown or grayish yellow loamy sand containing about 1.1 percent of organic matter, or 11 tons per acre.

The subsurface varies from a light brownish yellow to a yellow sand. It contains .7 percent of organic matter.

The subsoil is yellow sand.

Treatment.—In the management of this type, the principal problems are to prevent blowing and to maintain the supply of nitrogen. In this county there would be very little blowing of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are simply small areas, from a fraction of an acre to five acres in size, from which the sand is being blown. The sand from these blow-outs usually covers some better soil in the vicinity. The action of the wind may result in the ruin of the land if some protection is not given it. Wind erosion on this soil is worse than water erosion on other soils. Sand possesses very little cohesion, and it therefore is readily moved by the wind; but when organic matter is added this acts as a feeble cement that is sufficiently strong, however, to bind the particles together and thus prevent blowing.

To prevent the movement of sand by the wind, it is necessary either to have wind breaks, or to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing blowing. Every means should be used for increasing the organic matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn.

The plants that are best adapted to sand dunes are legumes, which to a very large extent are independent of the nitrogen in the soil. It is interesting to know that a few legumes have adapted themselves to the sand to a remarkable degree. The climbing wild bean is a legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases a ton or more to the acre is produced. It would seem that this plant might well be distributed over all the sand areas, especially those that are likely to blow.

Cowpeas are well adapted to growing on these sand soils. They furnish a large amount of organic matter to hold the sand and also the necessary nitrogen for growing other crops. Where wheat or rye is grown, the drill, with peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and

the wheat seeded in them, leaving the vines to protect the sand during the winter. Recent experiments show that two of the best crops for sand are sweet clover and alfalfa.

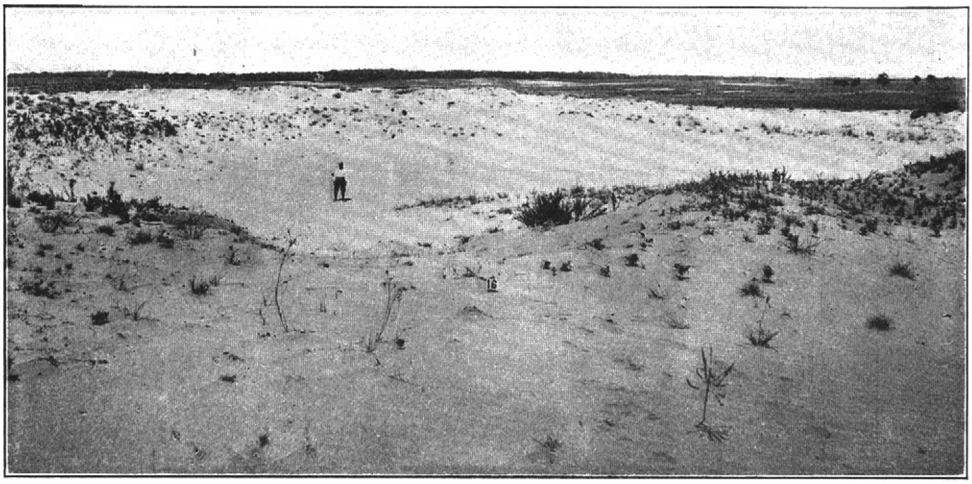


FIG. 1.—A LARGE "BLOW-OUT" WITH MANY SMALLER ONES IN THE DISTANCE
A SAND FARM MAY SOON BE RUINED BY NEGLECT

In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly spoken of by farmers as "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is more often due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will do much to prevent firing.

In the management of a crop on sandy land, cultivation should be practiced no more than is absolutely necessary and should then be as shallow as possible. Sand is naturally well adapted to prevent moisture from evaporating, and there is no necessity for any more cultivation than is really necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Foresting is a practical way of conserving these sand soils. Black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty that has been experienced is that the locust tree is damaged by borers; but if it is used to start a growth and hold the sand temporarily, other trees may then be interplanted with the result that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, so that the grass will not be entirely destroyed.

While the acidity is not high, the sand soil is entirely devoid of limestone. For satisfactory results, therefore, an application of from 2 to 4 tons per acre of limestone is recommended, and the supply should be maintained by subsequent applications every four or five years. When potash salts can be secured

at reasonable cost, their use is likely to produce profitable results, at least temporarily, in getting under way systems of permanent improvement. This applies more especially to the level areas, which were originally sandy swamps.

As the nitrogen content is exceedingly low, successful crop production on this type of soil rests upon the building up of the supply of this element, and this can be accomplished thru the growth of legumes as recommended above.

The phosphorus content of this sand type is not high, only 780 pounds per acre of this element being present in the plowed soil, but it exists to a considerable extent in other constituents than sand grains. This is shown by some work of the United States Bureau of Soils in which two types of sandy soil, glacial sand and sandy loam, were separated into coarse and fine particles. Each grade was analyzed for phosphorus, and it was found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, the limited amount of phosphorus contained in this dune sand would sooner or later become exhausted, altho field experiments might not indicate a need of phosphorus at first.

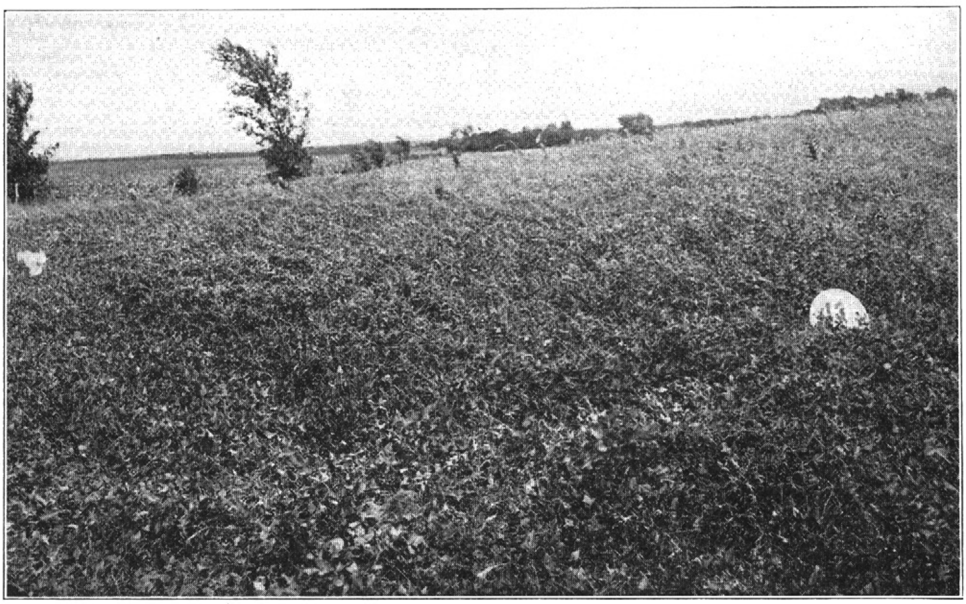


FIG. 2.—THE TRAILING WILD BEAN HOLDS THE SAND AND ADDS NITROGEN AND ORGANIC MATTER

The total supply of potassium is much smaller than is found in the more common soils. As to its availability for growing crops on sandy soils, field experiments have shown some discrepancies in results, owing probably to a variation in the condition in which the potassium exists. Definite recommendations, therefore, regarding the application of potassium to this type of soil must await the collection of more reliable information. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

For an account of field experiments on sand soil see page 70 of the Supplement.

Black Mixed Loam (1550)

Black mixed loam occurs in the terrace region in the northwest part of the county, principally in Town 18 North, Range 7 East. The total area covered amounts to 2,515 acres. The topography is flat with occasional slight undulations not more than two feet in height.

The surface soil, 0 to 6⅔ inches, is a black loam, so variable in composition that it cannot be divided into distinct soil types. Small areas may be peat, others peaty loam, black clay loam, or sandy loam, and this mixed character makes it impossible to separate it into distinct types. The surface stratum contains about 10.5 percent of organic matter, or 105 tons per acre.

The natural subsurface usually varies from 14 to 18 inches in thickness, and is a black mixed loam becoming drab or drabbish yellow with depth. The organic-matter content is approximately 3.9 percent, or 78 tons per acre in a stratum twice the thickness of the surface soil.

The subsoil is variable in composition and color, but usually consists of a mixture of clay, silt, sand, and gravel. It contains about 1.2 percent of organic matter.

Treatment.—This soil is very rich in organic matter, nitrogen, and phosphorus. The first thing to be considered in the management of this type is drainage, and the pervious character of the strata enables this to be accomplished very readily where the proper outlet can be obtained. This type contains many alkali areas, the treatment of which should be the same as that recommended for the alkali spots in the black sandy loam (1561) described above.

Black Silt Loam (1525)

Black silt loam is found in the terrace area of the western part of the county, and occupies the low, undrained areas of the higher part of the terrace. The total area amounts to 3,149 acres. The topography is flat with an occasional slight undulation of a foot or two. These higher parts are frequently strongly alkaline, and require special treatment before corn and oats can be grown successfully.

The surface soil, 0 to 6⅔ inches, is a black silt loam, which varies from a clayey silt, bordering on black clay loam, to a slightly sandy phase. Occasional patches which are very high in organic matter cause the type to grade toward clayey muck. This stratum contains about 6.1 percent of organic matter, or 61 tons per acre.

The natural subsurface, which is represented by a stratum 12 to 20 inches thick, is a black silt loam varying on one hand to a black clay loam, and on the other to sandy loam. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 5.9 percent of organic matter, or 118 tons per acre.

The subsoil is a blackish to drabbish yellow clayey silt or silty clay, frequently containing some pebbles and a considerable amount of sand in local areas. It contains about 2.1 percent of organic matter. In one area a bright, brownish yellow stratum about 2 or 3 inches in thickness was found in the subsoil. This material contained so much phosphorus as to cause the subsoil sample, 20 to 40 inches, to show over 33,000 pounds per acre.

Treatment.—The first requirement of this soil is drainage, and this, with good cultivation, is about all that is needed for the present.

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam occurs in the terrace in the northwest part of the county and covers 3,174 acres. It represents some of the higher areas, together with many sand dunes, that have been covered with finer material. The character of the soil has been somewhat modified by the growth of forests consisting principally of black oak (*Quercus marylandica*). The topography varies from flat to somewhat rolling, the latter condition being caused by sand dunes.

The surface soil, 0 to 6⅔ inches, is a yellow to grayish yellow and brownish yellow sandy loam, usually containing large amounts of sand and grading into dune sand in many places. On this type, many small areas, especially those having dune topography, could be mapped as sand, were the areas large enough. The surface stratum contains about 2.4 percent of organic matter, or 24 tons per acre.

The subsurface varies from a silty sand or even a sandy silt to pure sand, and is usually yellow in color. There is a decrease in the amount of organic matter in the subsurface, the analysis of which shows only .7 percent.

The subsoil consists of a yellow silty sand or sand.

Treatment.—The type is rather low in productiveness, due to the low organic-matter content. The best way to improve this condition is to turn under manures and all crop residues possible. The addition of limestone to the amount of 3 or 4 tons per acre will permit the growing of clover, which is so effectively used for soil renovation. Sweet clover could be used to excellent advantage on this type. The entire crop with the exception of the seed should be turned under.

Brown Fine Sandy Loam (1571)

In the northeast township of the county, there are several areas of brown fine sandy loam that aggregate 1,165 acres. This type varies in topography from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam, varying on one hand to a brown silt loam, and on the other hand to a brown medium sandy loam. It contains some small areas of ordinary sandy loam that represent low dunes. The organic-matter content is about 4.4 percent, or 44 tons per acre.

The natural subsurface is represented by a stratum 8 to 12 inches thick, and is a brown fine sandy loam, usually becoming more sandy with depth until it passes into a yellow silty sand. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter, or 38 tons per acre.

The subsoil is a yellow to a drabbish yellow silty sand, frequently passing into almost pure medium sand.

Treatment.—After drainage, the maintenance of organic matter and nitrogen is the principal consideration in the management of this type. Applications of 3 or 4 tons per acre of limestone should be made for the successful growing of clover.

Black Clay Loam (1520)

A few areas of black clay loam are found on the upper terrace that aggregate but 422 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam, varying toward a black silt loam. It contains about 7.5 percent of organic matter, or 75 tons per acre.

The natural subsurface, 10 to 18 inches in thickness, is a black to a dark drab clay loam, considerably heavier than the surface. The stratum as sampled (6⅔ to 20 inches) contains about 4.2 percent of organic matter, or 84 tons per acre.

The subsoil is a heavy drab to yellow clay loam, containing about 1.5 percent of organic matter. It contains in some cases a small amount of gravel.

Treatment.—Drainage is the first requirement of this type. In spite of the heavy character of the strata, drainage takes place readily, due to the joints in the soil produced by shrinkage in times of drouth.

In this type it is doubly necessary to maintain the supply of organic matter in order to keep the soil in good physical condition and to give it easy working qualities. Limestone also must be maintained for the same purpose.

Brown-Gray Sandy Loam on Tight Clay (1568)

Brown-gray sandy loam on tight clay is scattered over a considerable area of the terrace, but not in large tracts. The total area covered by the type is 1,562 acres, or .28 percent of the entire county. For some reason a large amount of very fine material has been deposited at variable depths in this type, which has resulted in producing a tight layer thru which water passes with great difficulty. This has changed the color of the subsurface soil to a gray, and has rendered the soil less valuable. The topography of this type is generally flat.

The surface soil, 0 to 6⅔ inches, is a brown to a grayish brown sandy loam. When freshly plowed, the grayish color becomes more evident shortly after a rain. Usually the gray shows up in small areas not more than three to six rods in diameter. This stratum contains about 2.8 percent of organic matter, or 28 tons per acre. In physical composition it varies somewhat toward a brown silt loam.

The natural subsurface is represented by a layer 8 to 12 inches thick which consists of a grayish sandy silt loam that varies to a gray sandy loam. The organic-matter content of the stratum 6⅔ to 20 inches is about 1.4 percent.

The subsoil is rather variable. The tight clay is not uniform in depth, but may occur at depths ranging from 16 to 30 inches. The thickness, too, is variable. The subsoil in general is a gray to yellowish gray sand with the tight stratum consisting of a sandy clay or a clayey sand.

Treatment.—Drainage is one of the first requirements of this type of soil. The presence of the tight clay stratum in the subsoil retards drainage to such an extent that the lines of tile must be placed not more than four or five rods apart, and even closer than this would be better. Deep-rooting crops are very desirable, especially sweet clover, but it must be remembered that inoculation and plenty of limestone are needed in growing it. The deep roots penetrate the tight clay layer and will in time render it more pervious. At the same time, organic matter must be added to the soil to increase granulation. As the limestone moves downward, it too has a beneficial effect on granulation and tends to make the soil more porous. Since the soil is acid, 4 or 5 tons per acre of limestone should be applied at first with about 2 tons every four years afterward.

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs principally along the streams in the eastern and southern parts of the county as terraces from 40 to 60 feet above the present bottom land. The total area amounts to 2,118 acres. The topography varies from flat to slightly undulating, in some cases with a rather steep incline to the present flood plain. The areas occur as remnants of the former fill along Bureau creek and its branches, and also along the Illinois river.

The surface soil, 0 to 6⅔ inches, varies from a grayish yellow to a yellow silt loam, containing about 1.6 percent of organic matter, or 16 tons per acre.

The subsurface is a yellow silt loam, with approximately .6 percent of organic matter.

The subsoil is a yellow silt to a clayey silt. The gravel stratum is from 38 to 60 inches beneath the surface.

Treatment.—The drainage is good, owing to the presence of the deep subsoil gravel. The organic-matter content is very low, and every means should be used for increasing it. Limestone should be applied to permit the growing of large crops of legumes for soil improvement. In addition to these, straw, corn stalks, and all manure possible should be turned back into the soil. Phosphorus should be applied as the type is somewhat deficient in this element.

Yellow-Gray Sandy Loam on Gravel (1564.4)

Yellow-gray sandy loam on gravel covers an area of 211 acres. It is almost entirely confined to the terraces along the Illinois river.

The surface soil, 0 to 6⅔ inches, contains about 1.7 percent of organic matter or 17 tons per acre.

The subsurface is a yellow silt loam, passing into sandy and gravelly silt, the gravel beginning at from 18 to 24 inches. The subsurface contains about .5 percent of organic matter.

The subsoil is a silty gravel.

Treatment.—This type of soil needs for its improvement all the organic matter that can be economically worked into it. Besides organic matter and nitrogen it is also in need of phosphorus and limestone. Since the gravel is so near the surface, the type is not a good one to resist drouth.

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel occurs along Bureau creek and covers an area of 77 acres.

The surface soil contains about 2 percent of organic matter, or 20 tons per acre. It is a light brown sandy loam, the sand being mostly coarse.

The subsurface contains approximately 1.2 percent of organic matter.

Treatment.—The gravel is but 16 to 24 inches beneath the surface, and this renders the type a poor one to resist drouth. Its treatment should be similar to that recommended for the preceding type.

Brown-Gray Silt Loam on Tight Clay (1528)

The area of brown-gray silt loam on tight clay is very small, amounting to but 109 acres. It does not differ in character from the upland type; therefore, for recommendations the reader is referred to the discussion of this type under upland soils. (See page 19).

Gravelly Loam (1590)

There are only 109 acres of gravelly loam in the terrace. This should receive the same treatment as the upland type bearing this name. (See page 19).

(d) SWAMP AND BOTTOM-LAND SOILS

The bottom land of the Illinoisan glaciation represents the older bottom lands, while the Iowan and early Wisconsin represent the newer ones. There is but little difference between the two.

Mixed Loam (1354, 1454)

The mixed loam is found along practically all the small streams of the county, forming flood plains varying from a few rods to a mile in width. It covers a total area of 39.81 square miles, or 4.61 percent of the area of the county. Mixed loam varies widely in physical composition, including small areas of sand, sandy loam, silt loam, and even clay loam. These are usually so badly mixed that a separation is not practical. During flood times, the character of the soil may be changed entirely.

The surface soil, 0 to 6⅔ inches, consists of a mixed loam containing from 3.6 to 6.1 percent of organic matter with an average of 4.9 percent, or 49 tons per acre. The surface soil varies widely, a distance of a rod often giving entirely different kinds of soil. Small areas of peat may occur.

The subsurface, to a depth of 20 inches, is a dark soil of varying texture, containing about 3.6 percent of organic matter.

The subsoil varies from a brown to a drab or yellowish clayey silt to sandy silt. It is sufficiently pervious for good drainage.

Treatment.—No applications of plant food are advised for this type of soil, since it annually receives deposits from overflow sufficient to maintain the fertility of the soil. It usually grows good crops unless damaged by overflow or by poor drainage.

Deep Peat (1401)

Deep peat occurs mainly in the terrace region of the northwest part of the county. The total area covered is 6,400 acres, or 1.16 percent of the area of the county. Some of these peat deposits are very deep. One in Section 11, Town 16 North, Range 7 East is said to be 65 feet deep, while the area in Sections 10 and 11, Town 17 North, Range 7 East, is from 30 to 40 feet deep.

The surface soil, 0 to 6⅔ inches, consists of a brown to black, fairly well-decomposed material containing from 31 to 56 percent of organic matter with an average of 43.7 percent, or about 220 tons per acre.

The subsurface soil consists of material that is usually less decomposed than that of the surface. The samples taken contained the same percent of organic matter as the surface.

The subsoil contains, as an average, about 31 percent of organic matter.

Treatment.—The first requirement of this type is drainage. The best form of drainage, especially at first, is the open ditch. Peat, because of its loose, uncompacted condition, does not furnish a very good bed for tile. This may be remedied, however, by putting a board in the bottom of the ditch and placing the tiles on that.

Characteristic of peat, this soil is extremely rich in nitrogen, is well supplied with phosphorus, but is very deficient in potassium, as compared with ordinary fertile soils. Where thoro drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is the only deficient element. Stable manure, as well as straw and other crop residues which contain a certain amount of potassium, can be used to supply this element, altho a more economical use of the manure is made when applied to soil that can utilize the nitrogen to better advantage than does peat. Experimental results, as obtained by the Experiment Station, as well as practical experience on the part of farmers, have demonstrated that kainit and the mineral potassium compounds such as the chlorid, sulfate, or carbonate of potassium, are used on this kind of land with great profit.

For an account of field experiments on deep peat the reader is referred to page 72 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay occurs almost entirely within the terrace region and it covers an area of 2,061 acres. The topography is usually flat.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, and contains about 44 percent of organic matter.

The subsurface is a sandy or clayey material containing about 20 percent of organic matter. The upper half of the subsurface is usually peaty, and the amount of organic matter gradually diminishes until at a depth of about 20 to 25 inches it passes into drab clay or clayey sand.

The subsoil varies largely in physical composition, but is usually a drab clay or a clayey sand.

Treatment.—The first requirement of this type is drainage. Owing to the peculiar make-up of this soil its method of management may be rather variable, particularly with respect to the application of potassium. The peaty layer of the surface is very deficient in potassium while at the same time there is a large store of this element in the clay lying at varying depths below the surface. Sometimes good crops are obtained at once after drainage has been effected. Sometimes but one application of potassium is required to start production. Sometimes the first crop is poor but subsequent crops become better owing to the accumulation of potassium near the surface brought up from below by the roots of the previous crops. Sometimes the gradual mixing of the materials of the upper and lower strata thru tillage produces a good effect. Now and then farmers report great success in improving this kind of land by deep plowing or subsoiling, whereby the clayey material becomes incorporated with the peaty substance.

Therefore, just what course to pursue in improving this land will depend to a large extent upon the depth of the peaty layer, and the farmer must be guided largely by experience. If, after thoro drainage has been effected, corn fails to grow well, the indication is that potassium is needed either to supply a natural deficiency or to overcome the effects of an alkaline condition that sometimes exists in this kind of soil.

Peaty Loam (1410)

Within the terrace region a large amount of peaty loam is found, the total area being 17.07 square miles, which is about 2 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, contains from 12 to 16 percent of organic matter. The mineral constituent is principally white sand.

The subsurface contains from 3.2 to 4.5 percent of organic matter, with an average of 3.8 percent.

The subsoil contains a little more than 2 percent of organic matter.

Treatment.—The first requirement of peaty loam is drainage. The types, peaty loam, (1410), black mixed loam (1450 and 1550), and black sandy loam (1461 and 1561) frequently have some areas which do not grow good crops, especially corn. The leaves of corn become striped with yellow, or turn yellow or brown. The growth is not large and the plant presents a leafy appearance due to the short joints of the stalk. These areas need potassium. It may be supplied by applying from 100 to 200 pounds per acre of potassium chlorid or potassium sulfate, or by turning under coarse manure, straw, or a green crop.

Much of the peaty loam contains spots of alkali, which are so strongly charged that grain crops will not grow. A crop of sweet clover turned under will be very beneficial on this alkali soil.

Black Clay Loam (1420)

Several small areas of black clay loam are found in the swamp region in Towns 16 and 17 North, Range 6 East. These cover a total area of 160 acres.

The surface soil, 0 to 6⅔ inches, is a black, plastic, very granular clay loam containing about 7.5 percent of organic matter, and grading in this respect toward clayey muck.

The subsurface is a black clay loam containing 4.2 percent of organic matter.

The subsoil is a dark drab clay loam containing 1.5 percent of organic matter.

Treatment.—Good drainage and good cultivation are the things necessary in the management of this type.

Black Silt Loam (1425)

Black silt loam is found in the low, swampy part in Towns 16 and 17 North, Range 6 East, occupying an area of 4,365 acres. The area is very flat and at one time was a lake or swamp.

The surface soil, 0 to 6⅔ inches, is variable in organic-matter content, but averages about 13 percent, or 130 tons per acre. In physical composition it varies from a black clayey silt to a black sandy loam with some small areas of peat or clayey muck.

The subsurface soil is a black clayey silt varying somewhat with the surface. It contains about 4.9 percent of organic matter.

The subsoil is drab to drabbish yellow in color. It contains 2.9 percent of organic matter.

Treatment.—The first requirement of this type is drainage, and after this is provided but little else is necessary other than good cultivation. Spots of alkali are found.

Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only in the bottom land of the Illinois river. It covers 8,256 acres. It is flat and usually so wet and swampy that it cannot be cultivated.

The surface soil, 0 to 6⅔ inches varies from a clayey silt to a silt loam in texture, and from brown to black in color. It contains about 7.5 percent of organic matter.

The subsurface contains approximately 4.2 percent of organic matter. It becomes somewhat heavier with depth.

The subsoil varies to a greater extent than either of the other strata. In some cases peat or muck has been covered by deposits during floods, and these now form the subsoil. In one sample taken, the subsoil contained two times as much organic matter as the surface.

Treatment.—Where the land is workable good cultivation is about all that is necessary in the management of this type.

Black Mixed Loam (1450)

A number of small areas of black mixed loam occur in Town 17 North, Range 6 East, covering 422 acres.

This soil is very similar to the terrace type of the same name (1550), and should be managed in the same manner.

Black Sandy Loam (1461)

Black sandy loam is found as a broad swampy plain along the Green river and covers 5,606 acres, or about one percent of the area of the county. The area is very flat.

The surface soil is a black sandy loam containing some clay and varying from a sandy clayey silt to a sandy loam with 65 to 70 percent of sand. It contains about 9.9 percent of organic matter, or 99 tons per acre.

The subsurface soil contains 4.2 percent of organic matter, and varies somewhat the same as the surface.

The subsoil is drab in color and varies in physical composition from a sand to a clay loam, the most common being a sandy to a gravelly clay. The organic-matter content is about 1.6 percent. The subsoil frequently contains fragments of calcium carbonate.

Treatment.—Drainage and good cultivation are necessary for this type. Alkali spots are rather abundant. For treatment of alkali spots, see description of this type in the terrace (1561), page 24.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	02	.01
Wheat straw.....	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	19	.07	.01	01
Corn stover......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	....	...
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test fo soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervesence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn. but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium. and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years. and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especcially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Bureau County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot. *In the grain system* no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0................	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R................	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M................	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL...............	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML...............	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP..............	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP..............	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK.............	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK.............	70.2	72 0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5..........	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

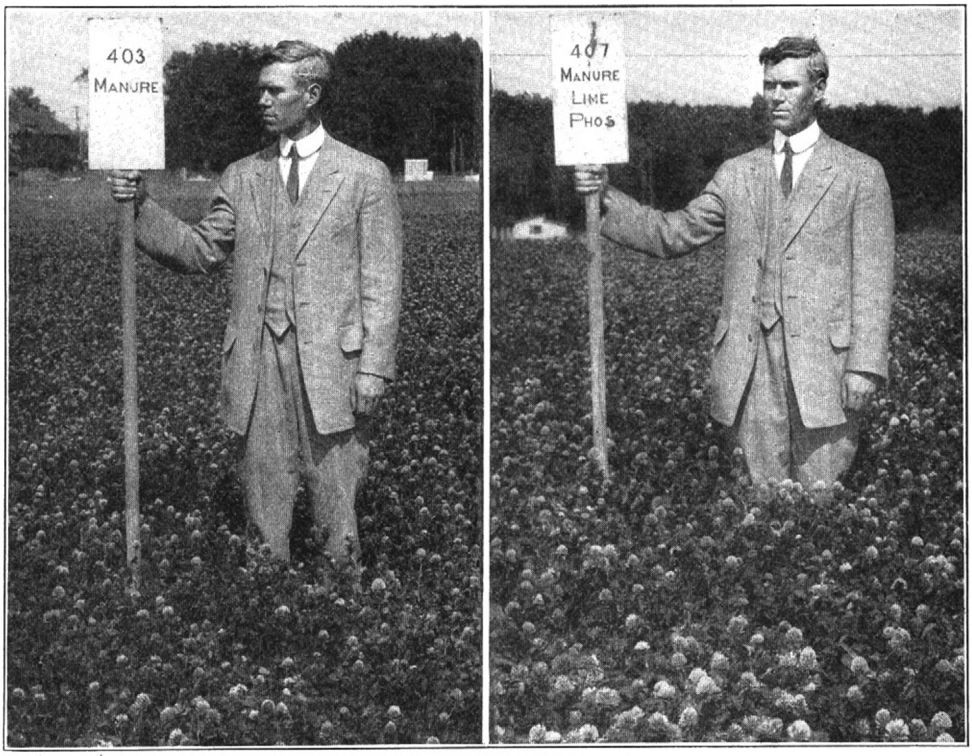
Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

Experiment Fields in Bureau County

It happens that there are two experiment fields located within the borders of Bureau county, one near La Moille and the other at Spring Valley. Both of these fields are on the brown silt loam of the early Wisconsin glaciation but the Spring Valley field represents a phase of the type that was formerly timbered.

The La Moille Field

The first experimental crops were grown on the La Moille field in 1910. Two cropping systems are being carried on. The main system is the standard rotation of wheat, corn, oats, and clover. In addition to this, a minor rotation of potatoes and alfalfa has been conducted on other plots in which potatoes occupied the land for two years and were followed by six years of alfalfa. This latter rotation was changed in 1921 to one consisting of corn, corn, wheat, and alsike clover. A diagram of the La Moille field, showing the arrangement of the plots, is presented as Fig. 4.

Table 6 shows the treatment of plots and the summarized results for the years since full treatment has been under way.

In considering these results it should be taken into account that this field is not altogether uniform. As a matter of fact some of the untreated, or check, plots are among those most favorably located, and this places upon many of the treated plots a handicap which will require time to overcome. The annual records, which are not given here in the summarized results, reveal the fact that progressive improvement is taking effect as a result of proper treatment. The increases due to proper treatment are much more marked in the later than in the earlier years, thus indicating that the treated plots are becoming better or the check plots are becoming poorer, or, what is more probable, that both of these effects are taking place.

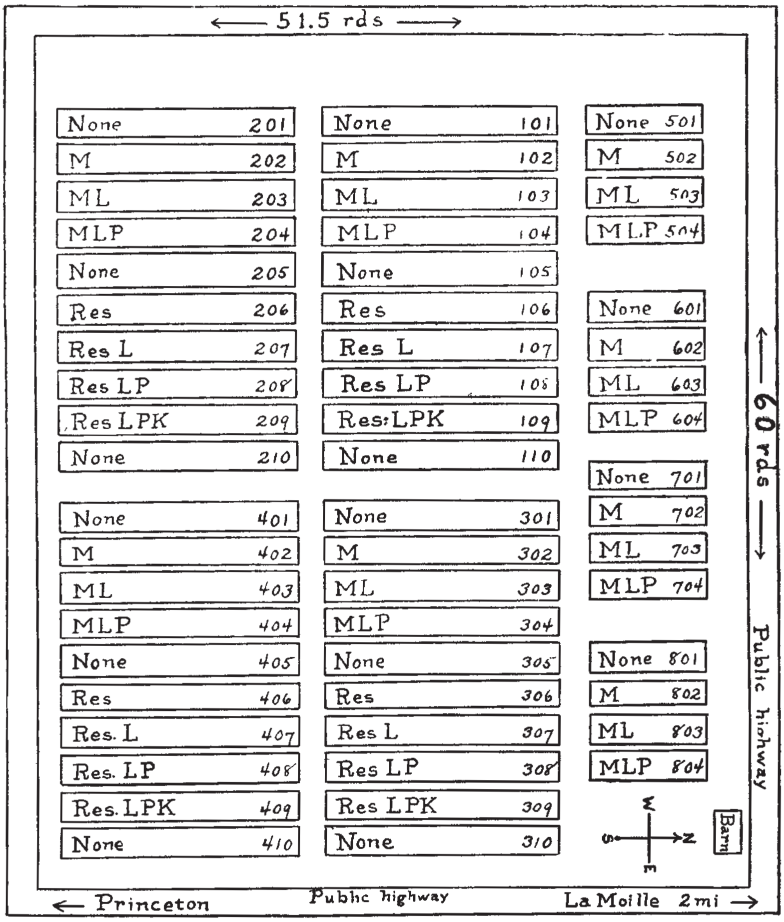


FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE LA MOILLE EXPERIMENT FIELD.

TABLE 6.—LA MOILLE FIELD: BROWN SILT LOAM, PRAIRIE; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Main Rotation: Wheat 6 crops	Corn 8 crops	Oats 8 crops	Legumes: Clover 6 crops: Hay	Clover 6 crops: Seed	Soybeans 1 crop: Hay	Soybeans 1 crop: Seed	Minor Rotation: Alfalfa 10 crops	Potatoes 8 crops
1	0.......	28.0	44.2	67.1	(2.46)	....	(2.20)	....	(2.34)	103 2
2	M......	37.9	54.4	73.7	(2.86)	....	(2.20)	....	(2.80)	135 8
3	ML.....	39.4	52.7	72.6	(2.90)	....	(2.18)	....	(2.83)	130.0
4	MLP...	39.2	53.2	70 8	(2 90)	....	(2.20)	....	(2.69)	121.8
5	0......	36.2	39.9	59 3	(96)	1.06	....	16 2	....	....
6	R......	38.2	48.4	72.0	(.95)	.67	....	16.8	....	....
7	RL.....	39.8	49.8	70.9	(1.05)	.73	....	16 6	....	....
8	RLP....	41.0	51.0	73 4	(1.04)	.82	....	14.4	....	....
9	RLPK..	40 9	49 1	71.1	(1 03)	89	....	14 7	....	..
10	0.......	31.1	37.4	61 8	(2.73)	....	(1.96)	....	....	....

The data thus far obtained indicate that the addition of organic matter to the soil, whether in the form of animal manures or plant manures, has produced beneficial effects. Limestone on the whole seems to have produced no marked effect on this field. Phosphorus has as yet returned no profit when applied with manure and limestone, but when applied in the residue system gains in yield in all of the grain crops are shown. It is probable that as time goes on, and the nitrogen supply becomes built up thru the incorporation of organic matter, phosphorus will become a limiting element and greater profit will result from its use. The application of potassium has produced no significant results.

The Spring Valley Field

The Spring Valley field is located on the grounds of the Township High School. This land was formerly timbered. The surface is very rolling. In fact, the contour is so uneven as to render the plot comparisons very difficult in some cases.

The field is laid out in two rotations, a major and a minor. The major crop rotation consists of wheat, corn, oats, and clover and occupies four series of plots with 12 plots in each series. The minor rotation, on the shorter series, consists of corn, corn (for silage), and oats (with sweet clover seeding) while alfalfa occupies the fourth series. Figure 5 shows the arrangement of these plots.

Inasmuch as this field has been so recently established and so few results have been obtained since full treatment has been in effect, no attempt is made at this time to summarize the results. However, for the benefit of those who are interested in watching developments on these plots, the tabulated yields of all crops harvested up to 1921 are presented in Table 7.

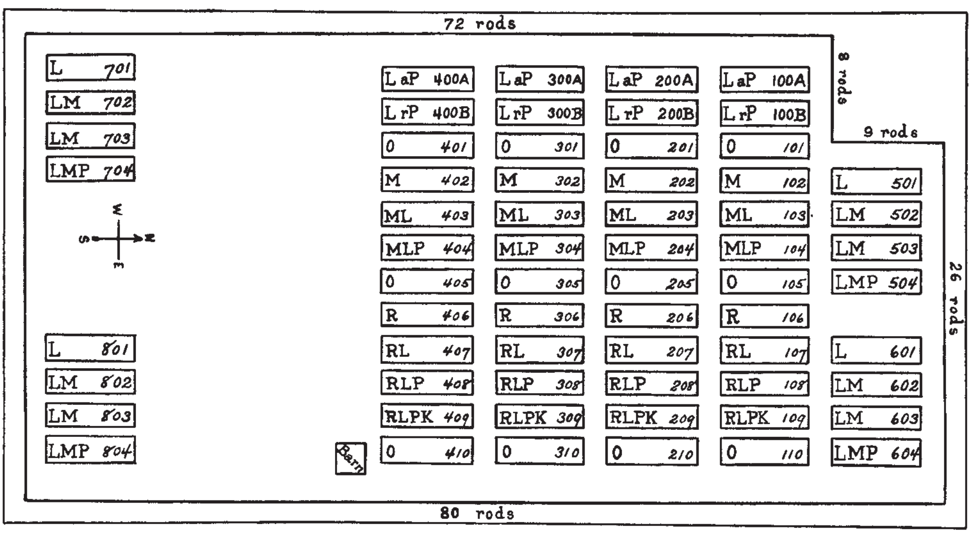


FIG. 5.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE SPRING VALLEY EXPERIMENT FIELD

TABLE 7.—SPRING VALLEY FIELD: BROWN SILT LOAM, FORMERLY TIMBERED; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1915[1]	1916	1917	1918	1919	1920
		Corn	Oats[2]	Clover[2]	Wheat[2]	Corn	Oats
100A[3]	L aP	....	....	....	....	....	....
100B[3]	L rP	....	....	....	....	....	....
101	0	34.8	35 9	(2.26)	53.2	41.6	55.3
102	M	27.8	32.5	(1.83)	46.0	42 4	51 6
103	ML	26.4	29.7	(2.36)	51 0	47 6	50.6
104	MLP	34.4	35.9	(2.40)	50.3	55.6	60.0
105	0	35.0	26.9	.03	55.3	43.6	50.6
106	R	30.4	31.2	.05	55.0	54 4	40 0
107	RL	31.2	34 4	.03	56 3	57.2	46.9
108	RLP	30.2	38 1	.05	57.2	56.8	52.2
109	RLPK	33.0	36.9	.03	49.7	66.0	58.8
110	0	35 0	35.9	(1.34)	45 2	30 8	48 1
		Wheat	Corn	Oats	Clover	Wheat	Corn
200A[3]	L aP	....	....	....	....	....	....
200B[3]	L rP	....	....	....	....	....	....
201	0	19.0	25 8	56.2	(3.84)	33.5	38.2
202	M	8.2	13.8	44.1	(4.26)	32.5	54 0
203	ML	6.3	10.4	39.1	(4.20)	32.7	53.8
204	MLP	15.5	17.8	49.7	(4.57)	34.3	55.0
205	0	15 8	14.6	40 9	(3.11) .25	33.5	39.0
206	R	15.5	19.8	39.7	(3.37) .42	30.8	47.4
207	RL	21.2	30.0	47.8	(3 55) .67	33.3	50 6
208	RLP	20.8	26.2	55.6	(3.77) 1.17	33.8	53.0
209	RLPK	18.8	25.0	42.2	(3.38) .50	31.3	53.4
210	0	13.5	20 2	42.5	(4.56)	31.5	35.6
		Soybeans	Wheat[2]	Corn	Oats	Clover	Wheat
300A[3]	L aP	....	....	....	....	....	....
300B[3]	L rP	....	....	....	....	....	....
301	0	(1 45)	26 0	23.6	46.6	(2.87)	25.3
302	M	(1 36)	17.3	32.4	45.9	(2.94)	23.8
303	ML	(1.40)	16 3	29.6	37.5	(2.72)	26.7
304	MLP	(1.54)	21 2	44.0	50.0	(3.42)	29.3
305	0	16.5	20 7	23.8	39.4	(1.58)	21.7
306	R	17.2	17.2	46.2	54.7	(2.04)	24.3
307	RL	17.3	23.8	48.0	55 0	(2.00)	33 8
308	RLP	17 5	19.2	45.6	62.2	(1.81)	33.5
309	RLPK	17.0	14.3	50 4	50.0	(1.95)	26 7
310	0	(1.36)	16 7	20.0	35.9	(2 70)	21 2
		Oats	Clover[2]	Wheat[2]	Corn	Oats	Clover
400A[3]	L aP	....	....	....	....	....	....
400B[3]	L rP	....	....	....	....	....	....
401	0	41.2	(2.31)	36.5	54.4	36.9	(2 23)
402	M	38.4	(2.00)	33.0	58.0	38 8	(2 48)
403	ML	23.1	(1 92)	32.8	57.2	39.1	(2 22)
404	MLP	34.7	(2.33)	38.2	63.6	40.9	(2.50)
405	0	33.8	.10	35 0	50.4	36.6	(1.46) 1.40
406	R	28.8	.17	37.3	57.2	34.7	(1.58) 1 87
407	RL	38.1	.12	39.3	67.6	54.1	(1 58) 1 95
408	RLP	32.5	.15	41.8	64.0	45.9	(1.68) 2 02
409	RLPK	38.8	.15	39 0	76.8	48.8	(1.47) 1 87
410	0	31.9	(2.33)	35.0	59.2	45.6	(2 39)

[1]Lime only. [2]No manure.

[3]In 1917 Plots A and B were added to each of the four series from 100 to 400 for the purpose of making a comparative phosphorus test. The treatment for this test was not begun until 1921. This treatment is as follows: on Plot A of each series, acid phosphate at the rate of 200 pounds per acre per year; on Plot B, finely ground rock phosphate at the rate of 400 pounds per acre per year; on both A and B, limestone at the rate of 500 pounds per acre per year, which is one-half of the usual rate.

An analysis of these yields shows that increasing gains for the better treatments are already being obtained, thus indicating that as time goes on the differences between the treated plots and the check plots will become more and more pronounced.

While it is far too early to draw final conclusions it is of interest to note a few points which the experiments seem to indicate. The possibility of building up this land thru the use of legumes and crop residues in connection with the application of limestone is already becoming apparent. While it is doubtful whether the gains produced by phosphorus are sufficient as yet to represent actual financial profit, it is altogether probable that the results will become more favorable for phosphorus as time goes on. As to the effect of potassium on this soil, it is clear that in the system of farming practiced, this material has been applied at a financial loss.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 8. The table also summarizes the yields, by crops, for the period during which the plots have been under full treatment.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

TABLE 8.—HARTSBURG FIELD: BLACK CLAY LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.
[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type generally shows a relatively high phosphorus content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

TABLE 9.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)		(.65)
2	M	29.7	13.0	7.7	(.31)		(.81)
3	ML	40.9	20.0	21.0	(1.08)		(1.08)
4	MLP	41.2	20.3	21.5	(1.32)		(1.24)
5	0	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 43 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

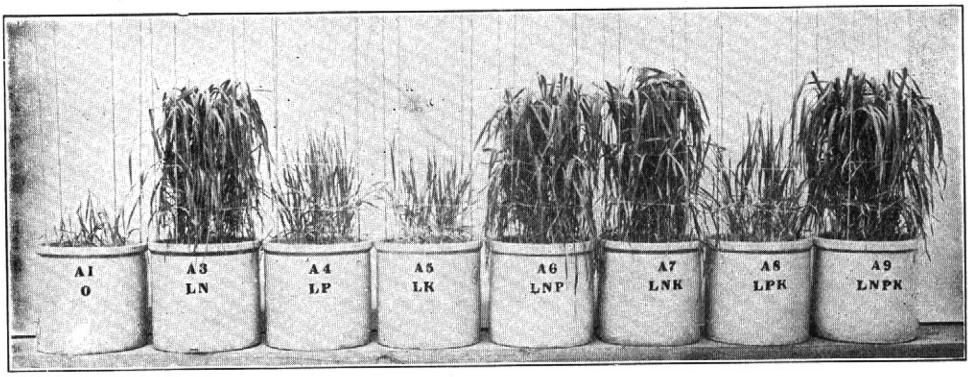


FIG. 7.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
The need of nitrogen (N) on this type of soil is clearly demonstrated.

TABLE 11.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND

Grams per pot

Pot No.	Soil treatment applied	Wheat	Oats
1	None	3	5
2	Limestone	4	4
3	Limestone, nitrogen	26	45
4	Limestone, phosphorus	3	6
5	Limestone, potassium	3	5
6	Limestone, nitrogen, phosphorus	34	38
7	Limestone, nitrogen, potassium	33	46
8	Limestone, phosphorus, potassium	2	5
9	Limestone, nitrogen, phosphorus, potassium	34	38
10	None	3	5
Average yield with nitrogen		32	42
Average yield without nitrogen		3	5
Average gain for nitrogen		29	37

However, some experiments in pot culture have been conducted with soil of this type, the results of which furnish useful data in indicating the proper management of this kind of soil.

In one experiment a large quantity of typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put into ten four-gallon jars. Wheat was planted in one series and oats in the other. Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 11.

As an average, the yield produced where nitrogen was applied, was about eight times as large as that secured without the addition of nitrogen.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa,

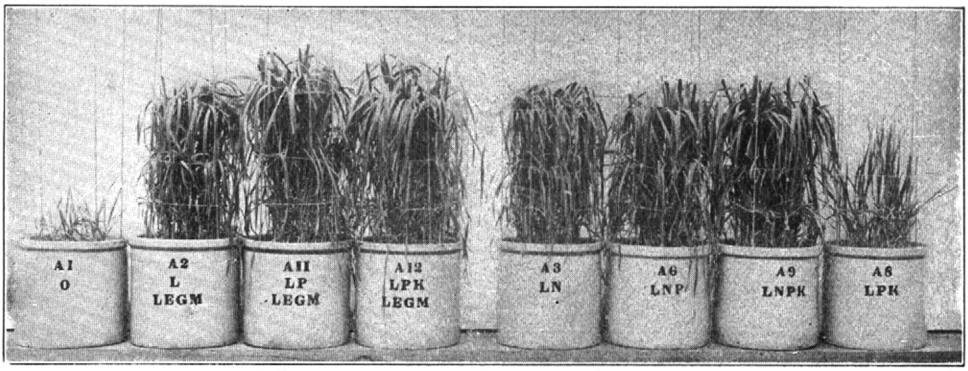


FIG. 8.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND

In the pots at the right, nitrogen is applied in commercial form. In the pots at the left, nitrogen is secured from the air thru the growing of legumes.

TABLE 12.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS

Grams per pot

Pot No.	Soil treatment applied	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None	5	4	4	4	6
2	Limestone, legume	10	17	26	19	37
11	Limestone, legume, phosphorus	14	19	20	18	27
12	Limestone, legume, phosphorus, potassium	16	20	21	19	30
3	Limestone, nitrogen	17	14	15	9	28
6	Limestone, nitrogen, phosphorus	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium	31	34	21	20	26
8	Limestone, phosphorus, potassium	3	3	5	3	7

sweet clover, cowpeas, and soybeans are worth raising not only because of their value as crops but because of their power, when properly inoculated with nitrogen-fixing bacteria, to secure nitrogen from the atmosphere.

In order to secure further information concerning the best practice in building up the nitrogen content, another experiment with pot cultures was conducted for several years with the same kind of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 12.

To three pots (Nos. 3, 6, and 9) nitrogen was applied, in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the green manure from legumes produced, as an average, somewhat better results than the commercial nitrogen. This experiment confirms the previous one in showing the very great need for nitrogen for the improvement of this type of soil—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume

crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care.

It may not be advisable in all cases to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value in increasing the organic matter and in preventing washing. Worthless slopes, where the land has been ruined by washing, may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa started well requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

DUNE SAND

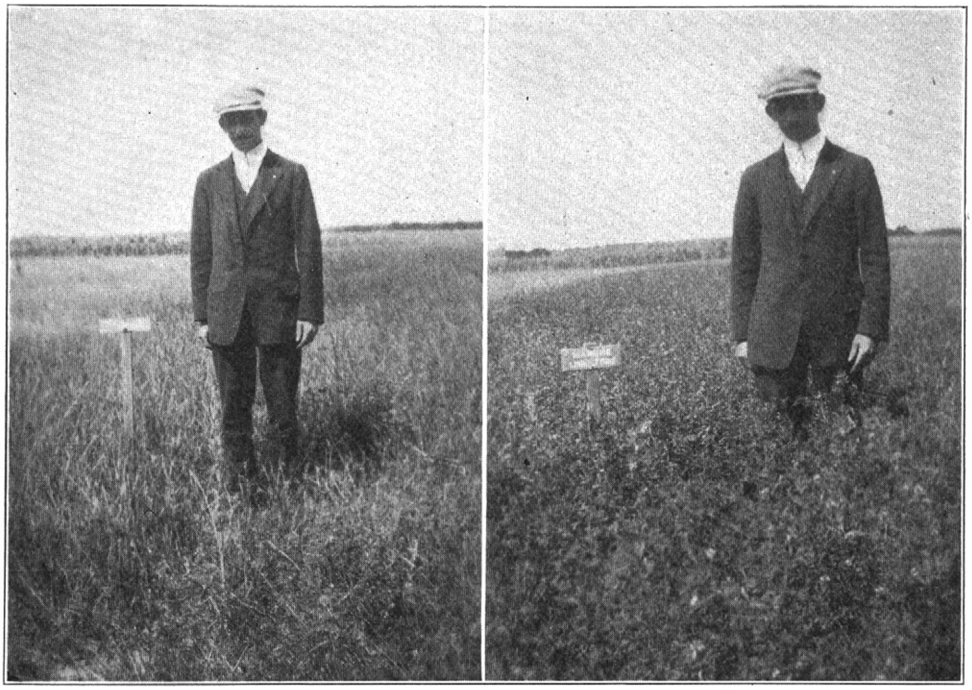
In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

Table 13 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 52.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.



Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 9.—ALFALFA ON OQUAWKA FIELD IN 1918

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two

TABLE 13.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soy-beans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops	Rye 4 crops	Alfalfa 3 crops
1	0...............	14.3	(.89)	6.4	0	12.1	(.11)
2	M...............	18.9	(1.01)	8.1	0	13.3	(.13)
3	ML.............	23.4	(1.27)	9.7	(1.20)	20.1	(1.88)
4	MLP...........	22.2	(1.20)	10.1	(1.26)	19.5	(2.03)
					2 crops 2 crops		
5	0...............	14.4	3.5	7.4	(0) 0	13.7	(.14)
6	R...............	16.2	3.5	8.1	(0) 0	14.1	(.12)
7	RL.............	29.3	6.6	9.1	(1.47) 2.53	23.2	(2.05)
8	RLP...........	29.3	6.4	10.4	(1.39) 2.20	24.2	(1.90)
9	RLPK.........	32.7	6.0	9.4	(1.53) 2.84	23.7	(1.86)
10	0...............	11.4	(.60)	6.4	(0)	10.6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 14.

The results of the four years' tests, as given in Table 14, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 14.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1	42 9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs	44.5	47.3	......
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0	164.5
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

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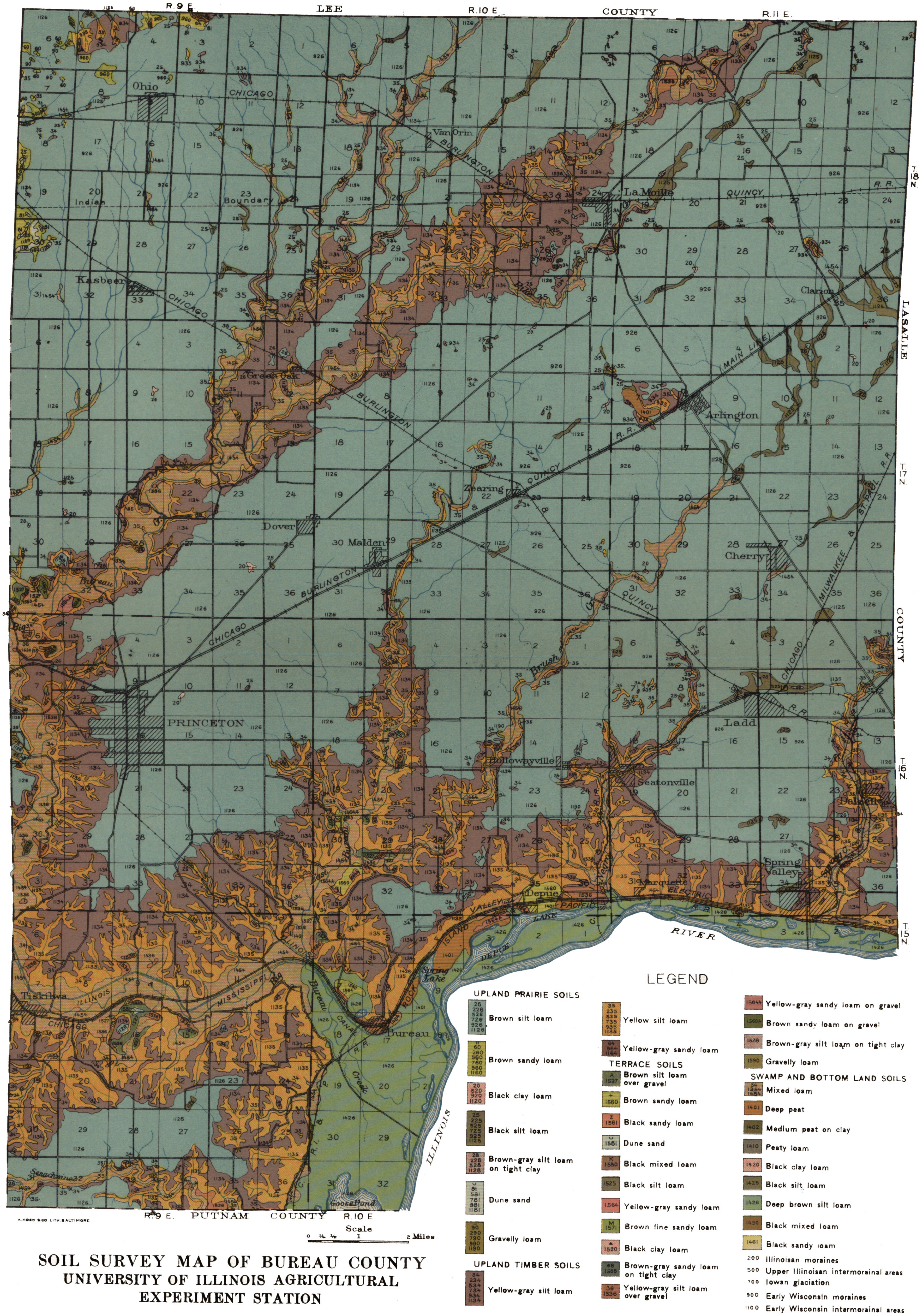
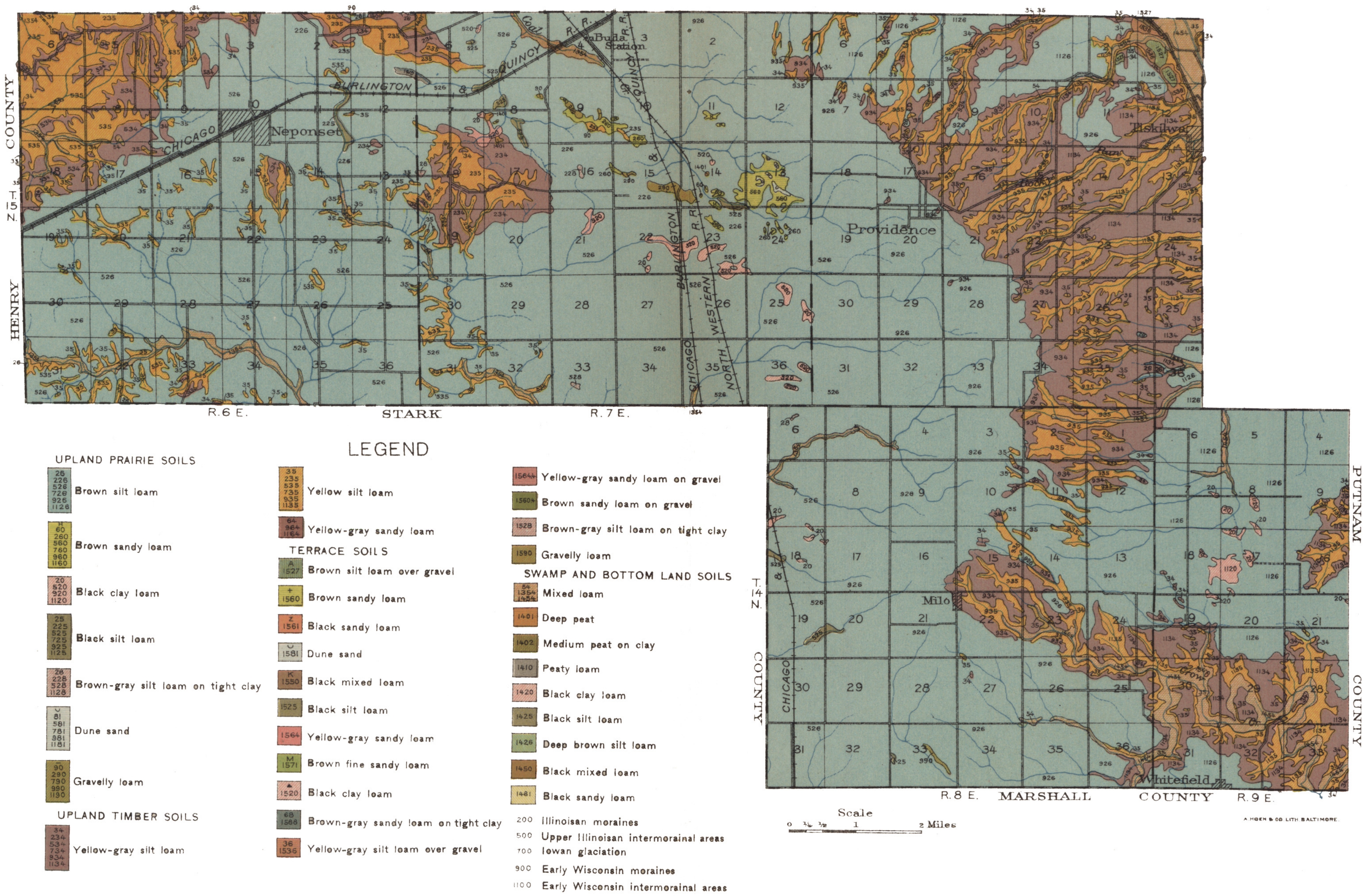


SOIL SURVEY MAP OF BUREAU COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL
EXPERIMENT STATION



SOIL SURVEY MAP OF BUREAU COUNTY
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LEGEND

UPLAND PRAIRIE SOILS

26 226 526 726 926 1126	Brown silt loam
60 260 560 760 960 1160	Brown sandy loam
20 520 920 1120	Black clay loam
25 225 525 725 925 1125	Black silt loam
28 228 528 1128	Brown-gray silt loam on tight clay
81 581 781 981 1181	Dune sand
90 290 790 990 1190	Gravelly loam

UPLAND TIMBER SOILS

34 234 534 734 934 1134	Yellow-gray silt loam
35 235 535 735 935 1135	Yellow silt loam
64 964 1164	Yellow-gray sandy loam

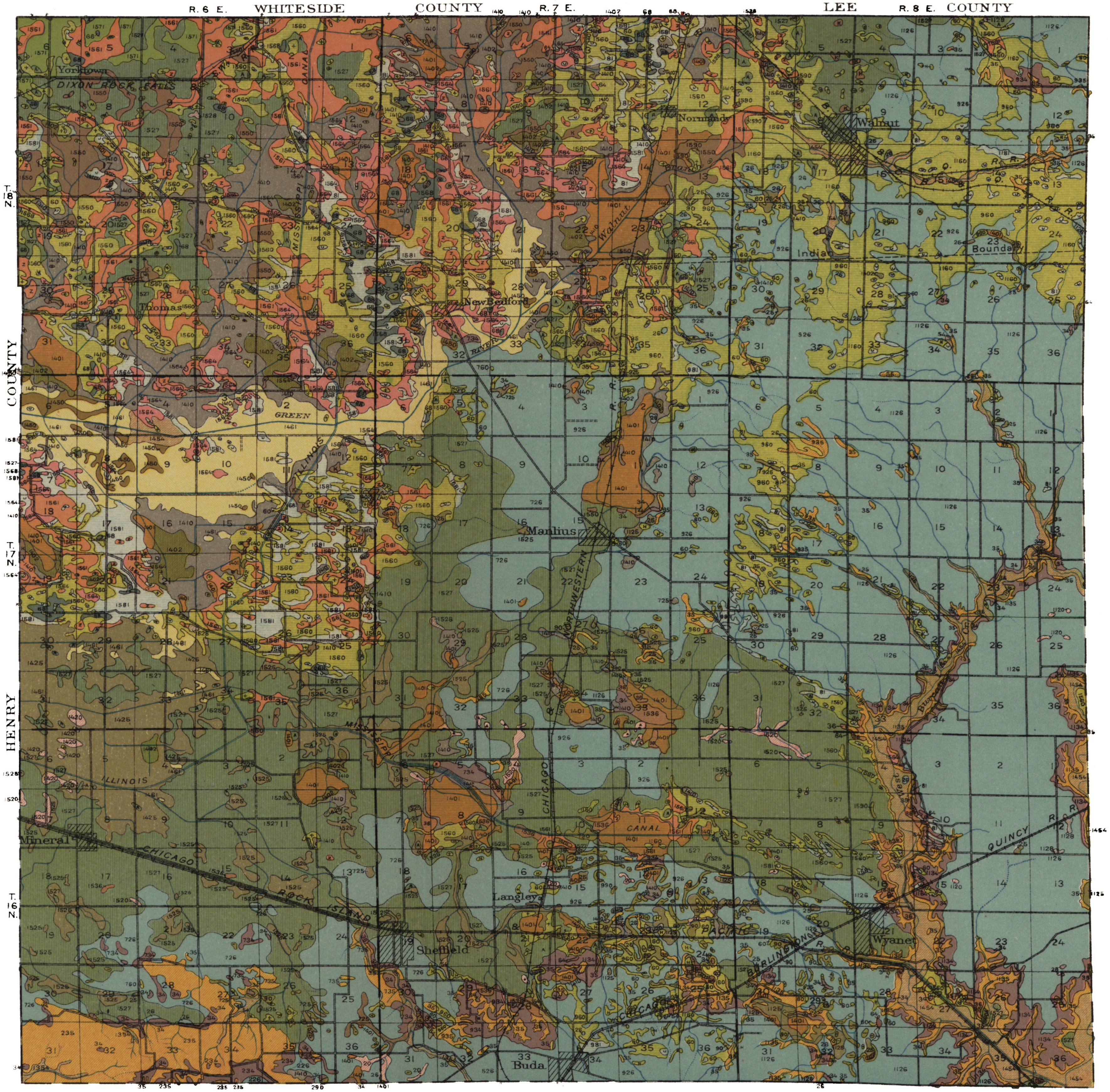
TERRACE SOILS

1527	Brown silt loam over gravel
1560	Brown sandy loam
1561	Black sandy loam
1581	Dune sand
1550	Black mixed loam
1525	Black silt loam
1564	Yellow-gray sandy loam
1571	Brown fine sandy loam
1520	Black clay loam
1568	Brown-gray sandy loam on tight clay
1536	Yellow-gray silt loam over gravel
1564	Yellow-gray sandy loam on gravel
1560	Brown sandy loam on gravel
1528	Brown-gray silt loam on tight clay
1590	Gravelly loam

SWAMP AND BOTTOM LAND SOILS

1354	Mixed loam
1401	Deep peat
1402	Medium peat on clay
1410	Peaty loam
1420	Black clay loam
1425	Black silt loam
1426	Deep brown silt loam
1450	Black mixed loam
1461	Black sandy loam

200 Illinoisan moraines
500 Upper Illinoisan intermorainal areas
700 Iowan glaciation
900 Early Wisconsin moraines
1100 Early Wisconsin intermorainal areas



Scale
0 ¼ ½ 1 2 Miles

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